New Frontiers in Regional Science: Asian Perspectives 10

Takao Ohkawa
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Regional Free Trade Areas and Strategic Trade Policies

Springer

New Frontiers in Regional Science: Asian Perspectives

Volume 10

New Frontiers in Regional Science: Asian Perspectives

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ISSN 2199-5974 ISSN 2199-5982 (electronic)
New Frontiers in Regional Science: Asian Perspectives
ISBN 978-4-431-55620-6 ISBN 978-4-431-55621-3 (eBook)
DOI 10.1007/978-4-431-55621-3

Library of Congress Control Number: 2016955701

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Japan KK

Preface

In the past few decades, a drastic and rapid movement of the world economy to globalization has intensified competition among many trading countries. As a result, the governments of those countries have been obliged to adopt various advantageous strategic trade policies and to seek the possibility of forming exclusive free trade areas (FTAs). Moreover, the technological developments of information and transportation system have enabled many commodities, previously non-tradable, to become tradable. Consequently, there appear many varieties of new tradable goods, some of which the trading countries, particularly importing countries, should pay attention to for sound trade.

This book focuses on those contemporary issues of international trade which have been arising because of globalization and technological developments. It aims to examine the key characteristics of those problems and to propose how to deal with those problems from both the world welfare and individual country welfare perspectives. Each chapter in this book is based on a theoretical analysis and contributes to the development of modern international trade theories. The four editors of this book are all Japanese scholars whose research field is primarily international trade theory. Because of this background, the topics treated in this book are typically formulated in the context of the Asian economy surrounding Japan. However, those topics are also applicable to international trade in any other geographical areas since they are, to varying degrees, commonly seen all over the world.

To focus on the Asian economy is significant not only because this economic region has been developing very rapidly but also because the economic impact of this region has become so powerful on the world economy. For example, the formation of FTAs can be seen to be quite active in the East Asian economic region. One of the most remarkable schemes of the FTA formation in this area is the Trans-Pacific Partnership Agreement (TPPA) advanced by the initiatives of US and Japanese governments, including 12 countries altogether in the East Asia and Pacific Rim regions. Once the FTA formed by this agreement has been established, it would have a tremendous economic impact on the world economy. Since the level of this agreement is said to be extremely high for free trade, it seems to be difficult for China to participate in this FTA. Against this background, China appears to be interested in forming an FTA with Japan and Korea. Moreover, the Japanese government also explores the possibility of establishing a broader FTA including both China and India, which is called Regional Comprehensive Economic Partnership (RCEP). Thus, there has been a dynamic development of FTAs in the Asian economy.

The formation of TPPA has taken many years to reach its final form. It originated from the economic partnership agreement between Singapore, New Zealand, Chile, and Brunei in 2006. Then, in 2010, the USA, Australia, Peru, Vietnam, and Malaysia participated in the TPPA development. Subsequently, Japan, Canada, and Mexico joined the TPPA in 2012. Thus, our interest is naturally placed on how an initially small FTA can become a larger FTA by adding new member countries. This is precisely one of the main topics in this book. The remaining topics in this book are strategic trade policies on intermediate goods, safe trade of food, and strategic behavior of trading firms, all of which are posed in the Asian economy context. There is a general concern for the theory of strategic trade policies throughout the book. We focus on this aspect of international trade since many countries adopt a strategic behavior approach in policy decision-making. The theory of strategic trade policies arose from the dispute on the trade friction between the USA and Japan in the 1980s. At that time, Japan was rapidly catching up to the USA economically through international trade with mainly the USA. The US government argued that the Japanese government had made full use of trade policy strategically to assist the Japanese exporting industries. Since then, various trade policies were captured as the strategic behavior of a government. For example, the US government newly introduced the Super 301 article as a trade policy. Afraid of the US retaliation, Japan adopted a voluntary export restraint in the automobile industry. These strategic behaviors on trade policies can be analyzed in a game theoretical framework.

The book is organized by four parts. Part I (Chaps. 1, 2, 3, and 4) is concerned with the formation of FTAs. Part II consists of two chapters (Chaps. 5 and 6) focusing on the timing of the introduction of trade policies by country governments. Part III contains various chapters (Chaps. 7, 8, and 9) relating to theoretical analyses of trade policies. Part IV (Chaps. 10 and 11) is devoted to the safe trade of food.

Chapter 1 investigates the possibility of a multilateral FTA by building bilateral FTAs in a three-country model where the market size of each country differs with that of other countries. It is shown that, if the market size is similar among all three countries, the multilateral FTA can be realized by welcoming a new member to the existing bilateral FTA. It is also shown that, in the case of overlapping formation of bilateral FTAs, starting from the bilateral FTA between the countries with the same size market, it is possible to attain a multilateral FTA in general if the remaining country has the market of a larger size than those of the other two countries. Chapter 2 focuses how the competition mode of firms affects the formation of FTAs in a similar framework to that employed in Chap. 1. The analysis reveals that the Cournot type of competition makes it easier to form the multilateral FTA rather than the Stackelberg competition.

A relevant topic in this part is the sustainability of FTAs after their formation. Chapter 3 considers this problem. Using the repeated game theory, this chapter examines whether the revenue-maximizing tariff regime or the welfare-maximizing tariff regime is more sustainable for an existing FTA. The result derived suggests that the former regime is more sustainable than the latter regime for a multilateral FTA but both tariff regimes are equally sustainable in the case of a bilateral FTA. Another interesting topic of this part is how the formation of an FTA influences the introduction of a new technology by firms though R&D activities. This is analyzed in Chap. 4. Using a three-country model of Brander and Spencer type, the analysis demonstrates that the formation of an FTA strengthens the incentive of member country firms to undertake R&D activities while it discourages the other country firms' R&D activities. It is also shown that the FTA may encourage or discourage the firms of the importing country to introduce a new technology.

To justify the introduction of a trade policy, the introducing government often claims that it is a response to existing trade policies adopted by competing country governments. Thus, one obvious problem is which country decides to be the first to introduce a trade policy. Chapter 5 examines this problem in the case of three countries, while Chap. 6 deals with it using a two-country model. There is a sharp contrast on the results obtained between these chapters. In the three-country model of Chap. 5, it is shown that, between two competing exporting countries, the government of the country where the smaller number of firms exists moves first and executes a subsidy policy to its domestic firms, whereas the government of the other country moves second and imposes an export tax on its domestic firms. In the two-country model of Chap. 6, the derived result is that, if the number of firms of the exporting country exceeds that of the importing country by more than three, the government of the exporting country moves first and imposes an export tax on its firms, while the government of the importing country moves second and imposes an import tariff on the foreign firms.

Chapter 7 deals with the long-run effect of the government trade intervention. The main result obtained is that, even with trade intervention by the government, the same circumstances as those of free trade could still be created in the long run where free entry of firms is allowed into the market.

In Chap. 8, the welfare-maximizing tariff regime and the revenue-maximizing tariff regime are compared and contrasted in terms of tariff level, output, and welfare of a country. It is shown in the chapter that, in more general circumstances than those in existing studies, the difference in the tariff levels between two regimes shrinks according to an increase in the marginal cost difference between home and foreign firms.

The topic of Chap. 9 is on how the levels of import tariff are affected by the cost asymmetries in final good production and the cost difference in intermediate good production between home and foreign firms in a two-country model with vertically related industries and markets. It is demonstrated that the country with higher final good production cost relative to the intermediate good production cost may levy an import tariff whose ratio to an import tariff on the intermediate good is lower.

In Part IV, our attention is centered to the trade of a very special good, that is, food, whose trade requires great care since it is fundamentally concerned with consumers' health and it is quite difficult to fully detect harmful food in the imported food. Chapter 10 considers the strategic tariff policy adopted by a food-importing country in order to protect the national consumers from taking the unhealthy food in the case where foreign firms strategically mix such food to cut down their production costs. The main conclusion is that, for any given inspection expense, the optimal tariff level is simply the one to just cover the expense by the tariff revenue.

Chapter 11 analyzes how international competition of food supply deteriorates food safety. This is discussed in relation to economic growth as well as population growth. The analysis asserts that a food price hike appears by economic growth, population growth of certain types, and the deterioration in the food quality of the South-type countries.

Because of the dynamic and rapid movement of Asian economy where Japan and China are located, there are many attractive trade topics to tackle. One of the most interesting and significant themes is trade of infrastructures which is growing tremendously. Most Asian countries with a rapid economic growth lack hard infrastructures such as transportation, irrigation, electricity, etc. as well as soft infrastructures like law system, efficient market mechanism, education system, etc. China, France, Germany, Japan, and the USA are straggling with each other to export public infrastructures to Asia. Though we do not include any study of this broad field in this book, this should be explored intensively in the near future.

All chapters except Chaps. 5, 6, and 11 are almost newly written for this book. Initially Takao Ohkawa, Makoto Okamura, Ryoichi Nomura, and Makoto Tawada planned the publication of this book in the course of their joint work on theoretical analyses of trade policies focusing on the policy timing and formation of FTAs. Then Masayuki Hayashibara, Yasushi Kawabata, and Madoka Okimoto kindly joined their plan by adding their papers to the book. We greatly appreciated their cooperation. We also thank Yordying Supasri who agreed to use his joint paper for Chap. 6. Chapters 5, 6, and 11 are, respectively, based on the paper, "Endogenous timing and welfare in the game of trade policies under international oligopoly," written by Takao Ohkawa, Makoto Okamura, and Maokto Tawada and published in Alan D. Woodward (ed.), *Economic Theory and International Trade: Essays in Honour of Murray C. Kemp*, Chap. 14, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing; "Endogenous timing in a strategic trade policy game: a two-country oligopoly model with multiple firms," written by Yordying Supasri and Makoto Tawada and published in *Review of International Economics*, vol. 11, pp. 275–290, 2007; and the paper,"International price competition among food industries: the role of income, population and biased consumer preference," written by Madoka Okimoto and published in *Economic Modelling*, vol. 47, pp. 327–339, 2015. We deeply acknowledge the publishers Edward Elgar, John Wiley & Sons, and Elsevier for permitting us to use/reuse these materials for Chaps. 5, 6, and 11, respectively. Finally, we are very grateful to Professor Binh

Tran-Nam of the University of New South Wales for some constructive comments to our manuscript and Mr. Yutaka Hirachi of Springer Japan for his efficient assistance to our editorial work.

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Part I
The Formation of Free Trade Agreements

Chapter 1
Expansion of Free Trade Agreements, Overlapping Free Trade Agreements, and Market Size

Ryoichi Nomura, Takao Ohkawa, Makoto Okamura, and Makoto Tawada

Abstract This chapter investigates whether the formation of bilateral overlapping free trade agreements (FTAs) between dissimilar countries becomes a building block or a stumbling block for multilateral free trade (MFT). Our main conclusions are as follows. Suppose that a bilateral FTA between symmetric countries is already formed. (i) A bilateral FTA becomes a stumbling block for MFT through overlapping FTAs, while it acts as a building block for MFT through expansion of FTAs when market sizes of member and nonmember countries are quite similar. (ii) When the market size of a nonmember country is smaller than that of member countries, then overlapping FTAs lead to MFT, while FTA expansion may or may not. (iii) If the nonmember country of the original FTA is large, then expansion of the FTA may not achieve MFT, while overlapping FTAs cannot. (iv) When the market size of the nonmember country is quite large compared with member countries, MFT never arises through overlapping FTAs, FTA expansion, or negotiation of a multilateral trade agreement.

Keywords Expansion of FTA • Overlapping FTA • Hub and spoke • Building block • Stumbling block

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*,
New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_1

1.1 Introduction

In recent decades, many countries and regions have attempted to form regional trade agreements (RTAs). According to WTO (2015), as of 7 April 2015, there were 406 RTAs notified to GATT/WTO. The number of RTAs has been growing rapidly since the early 1990s.[1] We observe three noteworthy features of recent RTAs: (i) a majority of the recently established RTAs are bilateral agreements; (ii) most of the recent RTAs are free trade agreements (FTAs); and (iii) FTAs between dissimilar countries have increased, whereas in the past, most FTAs were formed between similar countries. According to Fiorentino et al. (2009), as of December 2007, bilateral agreements account for 76 % of all RTAs that are notified and in force and 93 % of those that are signed and under negotiation.[2] FTAs account for 82 % of all RTAs that are notified and in force and 93 % of those that are signed and under negotiation. The major clusters of RTAs are north-south RTAs, accounting for 37 % of all RTAs notified and in force, and 56 % of those that are signed and under negotiation. A majority of overlapping FTAs are bilateral FTAs between dissimilar countries, while FTAs between developed countries were generally formed earlier.

These observed features of recent RTAs raise questions regarding whether the formation of a bilateral FTA between dissimilar countries with an existing FTA between similar countries becomes, as Bhagwati (1993) claimed, "a building block" or "a stumbling block" for multilateral free trade (MFT) and how asymmetry in market size affects the feasibility of FTAs and the realization of MFT through bilateral FTAs.[3] However, to our knowledge, this issue has received little attention because the above features of RTAs are the latest trends in the global arena. Therefore, taking the recent features of RTAs into account, we investigate how the difference in market size among countries affects the feasibility of MFT. In this chapter, we use the expression "building block" to indicate that the formation of a bilateral FTA eventually leads to MFT, while "stumbling block" implies that it hampers the establishment of MFT.

[1] These numbers include notifications made under GATT Article XXIV, GATS Article V, and the Enabling Clause. Further details are available at the WTO web page at http://www.wto.org/english/tratope/regione/regione.htm.

[2] We should note that in Fiorentino et al. (2009), bilateral agreements may include more than two countries when one of them is an RTA.

[3] Baldwin (2006) pointed out that the multilateralization of existing and emerging regionalism is required in order to achieve global free trade under circumstances in which regionalism is permanent and unlikely to change; further, he considered the role of the WTO in the multilateralization of regionalism.

Previous studies have examined some aspects of RTAs.[4] One strand conducts static analysis of RTAs and investigates the endogenous formation of bilateral FTAs (e.g., Freund, 2000; Endoh, 2006). In these studies, it has not been determined whether a bilateral FTA leads to MFT. The other strand conducts a dynamic time-pass analysis, so called by Bhagwati (2008), which relates to this chapter. This strand considers whether the formation of RTAs serves as a building block or a stumbling block for MFT (e.g., Krishna, 1998; Yi, 1996, 2000; Ornelas, 2005a,b; Aghion et al., 2007). These analyses assume that all countries are *symmetric* in most cases.[5] These assumptions do not necessarily match the features of recent RTAs; that is, dissimilarity among countries is frequently observed.

Moreover, we should note that, in these analyses, RTA expansion tends to be considered to occur only through expansion in the membership of existing RTAs and not through the creation of new RTAs. As Mukunoki and Tachi (2006) investigated, another way of expanding RTAs exists through the formation of overlapping FTAs.[6] When one of the member countries of the existing FTA forms another FTA with a nonmember country, then a hub-and-spoke system develops.[7] Mukunoki and Tachi (2006) assumed that countries are symmetric and showed that even if an expansion of bilateral FTAs through new memberships cannot achieve MFT, the formation of overlapping FTAs can generate free trade.[8] Nomura et al. (2013) introduced market asymmetry into the similar three-country model and showed that formation of a bilateral FTA acts as a building block for MFT through overlapping FTAs only when the initial FTA is formed between two larger countries, and the bilateral FTA cannot be expanded by the addition of a new member.[9] We should note that Nomura et al. (2013) assumed that all countries are different with respect to market size.

As mentioned above, while FTAs between similar countries were generally formed earlier, FTAs between dissimilar countries have proliferated recently, and these FTAs often overlap. To take these features of recent RTAs into account, we confirm the condition of forming a bilateral FTA and then investigate whether an overlapping FTA and FTA expansion lead to MFT in the presence of the

[4]See Bhagwati (1993) and Panagariya (2000) for a survey.

[5]Ornelas (2005b) partly introduced market asymmetry. Krishna (1998) also considers the asymmetry of market size.

[6]We should note that overlapping agreements can be formed only when the existing RTA is an FTA. If an existing PTA is a CU, then each member country cannot negotiate individually with nonmember countries.

[7]For example, Chile is attaining the position of a hub country, creating or negotiating FTAs with New Zealand, Brunei, Singapore, China, India, Japan, and other countries. Singapore and Thailand have also become active in the formation of bilateral FTAs in recent years.

[8]Mukunoki and Tachi (2006) assumed that the tariff level is exogenous and the external tariff remains at the same level after any FTA is formed.

[9]Saggi and Yildiz (2010) considered similar issues in a different model (i.e., competing exporters' model) and showed that when countries have asymmetric endowments, global free trade can be a stable equilibrium only when countries can form bilateral agreements.

original FTA between similar countries, introducing asymmetric market size and endogenous external tariffs.[10]

Our model is related to that of Saggi (2006), who considered whether RTAs are building or stumbling blocks for multilateral tariff cooperation in an infinitely repeated game with three countries. However, there are important differences between our model and that of Saggi (2006). Saggi (2006) investigated the effects of RTAs on the degree of multilateral tariff cooperation. In contrast to our model, Saggi (2006) did not consider the effects of both expanding and overlapping RTAs. In addition, he assumed that a single RTA is exogenously given, whereas we investigate the endogenous formation of FTAs and examine whether this formation acts as a building or a stumbling block for MFT.

Our main conclusions are as follows: Suppose that a bilateral FTA between symmetric countries is already formed. (i) A bilateral FTA becomes a stumbling block for MFT through overlapping regimes, while it acts as a building block for MFT through an expanding regime when market sizes of member and nonmember countries are quite similar. (ii) When the market size of nonmember country is smaller than that of member countries, then overlapping regimes lead to MFT, while expanding regimes may or may not. (iii) If the nonmember country of the original FTA is large, then the expanding regime may not achieve MFT, while the overlapping regime cannot. (iv) When the market size of the nonmember country is quite large as compared with member countries, MFT never arises through overlapping regimes, expanding regimes, or negotiation of a multilateral trade agreement (MTA).

The rest of this chapter is organized as follows. Section 1.2 develops the model. Section 1.3 shows the preliminary results. The feasibility of overlapping FTAs as well as FTA expansion are considered in Sect. 1.4. Section 1.5 investigates whether overlapping FTAs and FTA expansion lead to MFT. Section 1.6 concludes the chapter.

1.2 The Model

Consider a world economy with three countries, denoted by country 1, 2,and 3. Each country has a single local firm and a domestic market. We assume that the markets are segmented. The demand function of market i ($i = 1, 2, 3$) is given by the following:

$$P^i = 1 - d^i Q^i, \tag{1.1}$$

[10] Ornelas (2005b) endogenized the external tariff in Krishna (1998)'s model. He demonstrated that the formation of a bilateral FTA reduces nonmember countries' benefits from MFT and may thereby serve as a stumbling block for MFT.

where $Q^i = q_1^i + q_2^i + q_3^i$ is the total quantity supplied to market i and q_j^i is the quantity supplied by the firm in country j to market i. Each government i imposes a specific tariff t_j^i on imports from country j. All firms compete *à la* Cournot in all markets. We assume that firms have an identical cost function and normalize the production cost to zero. Further, there are no transportation costs among the markets. The profits of firm j in market i are given by

$$\pi_j^i = (P^i - t_j^i)q_j^i. \tag{1.2}$$

The welfare function of country i is the sum of consumer surplus, producer surplus of its local firm, and the tariff revenue, represented by

$$W^i = \frac{(1-P^i)Q^i}{2} + (\pi_i^i + \pi_i^j + \pi_i^k) + t_j^i q_j^i + t_k^i q_k^i. \tag{1.3}$$

In the initial situation, there is no FTA. Therefore, each government sets its specific tariff independently so as to maximize its national welfare. We assume that only one FTA is negotiated at a time and that no FTA is dissolved after its formation. Governments engaging in the present negotiation are interested in knowing whether the formation of an FTA improves national welfare, as compared with the status quo. However, they are not concerned about how the present FTA influences future negotiations over other FTAs.[11]

In the first round, two of the three governments negotiate to form a bilateral FTA. Now, suppose that one bilateral FTA is formed. Given that this situation is status quo, another negotiation will also be conducted. There are two possible paths to MFT after the formation of a bilateral FTA. (i) When both members of the existing bilateral FTA agree to accept the nonmember country as a new member, MFT is realized (*expanding regime*). (ii) When one of the bilateral FTA members forms another FTA with a nonmember country, a hub-and-spoke system arises. Under the hub-and-spoke system, two spoke countries can negotiate an FTA (spoke-spoke FTA), which leads to MFT (*overlapping regime)*. Therefore, two rounds occur in an expanding regime, whereas three rounds occur in an overlapping regime. Figure 1.1 shows the timeline, while Figure 1.2 illustrates the possible paths to MFT under both expanding and overlapping regimes.

Each round proceeds as shown in the following three-stage game. In the first stage, governments negotiate for an FTA. Given the initial situation (pattern of existing FTAs), the countries engage in an FTA negotiation. These countries then choose their unilateral stance on the FTA, that is, whether to participate or not. Each government chooses to participate only when the resulting social welfare is higher under the newly formed FTA than under the status quo. The FTA will be formed when all the governments involved in the negotiation choose to participate.

[11] Such a myopic assumption of players is also assumed in the literature on the process of network structure. See, for example, Watts (2001).

Fig. 1.1 Timeline

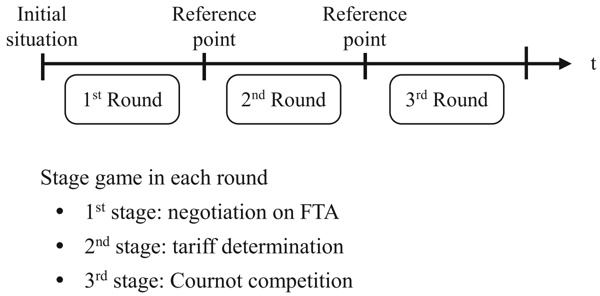
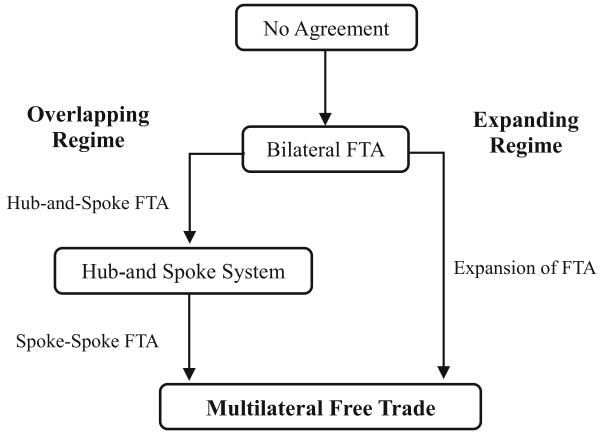


Fig. 1.2 Possible Paths to Multilateral Free Trade



Otherwise, no FTA is formed, and the status quo continues. In the second stage, all governments set their import tariff so as to maximize social welfare independently and simultaneously. When an FTA is formed, the governments of member countries do not impose any internal tariff; they only set an external tariff. In the third stage, firms compete *à la* Cournot in all markets, given the tariff levels set by the governments in the previous stage. We solve this game in each round by backward induction.

1.3 Preliminary Results

In this section, we first consider the outcome in the initial situation where no FTA exists, and then we confirm the feasibility of bilateral FTA.

1.3.1 Initial Situation: No FTA

First, let us confirm the outcome in the initial situation where no FTA is formed. That is, each government sets its tariff rate independently. In the third stage, given t_j^i, firms compete *à la* Cournot in all markets. Note that we can treat each market separately because the marginal costs are constant (zero). From Eqs. (1.1) and (1.2), the profit-maximizing quantity by firm j in market i is given by

$$q_j^i = \frac{1}{4d^i}\left(1 + \sum\nolimits_{h=1,2,3} t_h^i\right) - t_j^i. \tag{1.4}$$

In the second stage, each government determines the tariff level so as to maximize national welfare. From Eqs. (1.1) through (1.4), the social welfare of country i is given by the following:

$$\begin{aligned} W^i = {} & \frac{1}{32d^i}(3 - t_j^i - t_k^i)^2 \\ & + \left[\frac{1}{16d^i}\left(1 + t_j^i + t_k^i\right)^2 + \frac{1}{16d^j}\left(1 - 3t_i^j + t_k^j\right)^2 + \frac{1}{16d^k}\left(1 - 3t_i^k + t_j^k\right)^2\right] \\ & + t_j^i\left(\frac{1}{4d^i}(1 - 3t_j^i + t_k^i)\right) + t_k^i\left(\frac{1}{4d^i}(1 + t_j^i - 3t_k^i)\right), j, k \neq i. \end{aligned} \tag{1.5}$$

The first term represents consumer surplus; the terms within the square brackets denote producer surplus, and the sum of the third and last terms indicates the tariff revenue in country i. Maximizing Eq. (1.5) with respect to t_j^i given t_k^i, we have the first-order conditions:

$$t_j^i = \frac{3 + 11t_k^i}{21},\ t_k^i = \frac{3 + 11t_j^i}{21}. \tag{1.6}$$

Eq. (1.6) shows that the optimal tariff level does not depend on the tariff level set by other countries. This is owing to the assumption of segmented markets.

Noting that the most favored nation (MFN) clause of GATT requires that a country's import tariff should not depend on the country from which the import originates, we obtain optimal tariff level when no FTA is formed from Eq. (1.6):

$$t^{MFN} = (t_j^i)^* = \frac{3}{10},\ i, j = 1, 2, 3. \tag{1.7}$$

Eq. (1.7) satisfies the MFN clause.

Table 1.1 Social welfare without an FTA

	W^i
Country 1	$\frac{1}{100}(\frac{40}{d^1} + \frac{1}{d^2} + \frac{1}{d^3})$
Country 2	$\frac{1}{100}(\frac{1}{d^1} + \frac{40}{d^2} + \frac{1}{d^3})$
Country 3	$\frac{1}{100}(\frac{1}{d^1} + \frac{1}{d^2} + \frac{40}{d^3})$

Because there is no FTA in the initial situation, no government takes action in the first stage. Thus, Eq. (1.7) shows the equilibrium tariff rates.

Substituting Eq. (1.7) into Eq. (1.5), we obtain social welfare as shown in Table 1.1.

1.3.2 Feasibility of Bilateral FTA

Now, we consider whether a bilateral FTA can be formed. Even in the FTA negotiation process, the outcome of the third and second stages is the same as those in the case of no FTA, such as Eqs. (1.4) and (1.6). In the first stage, governments negotiate whether they can form an FTA. Note that we restrict our attention to the situation where only one FTA is negotiated at once and where no FTA is dissolved after its formation.

Suppose that an FTA between countries 1 and 2 is formed. In this case, governments 1 and 2 do not set any internal tariffs ($t_2^1 = t_1^2 = 0$) and impose an external tariff against nonmember country 3, so as to maximize their own national welfare. In contrast, government 3 does not change the tariff level on imports from countries 1 and 2. Thus, the formation of the bilateral FTA does not change the quantity supplied to market 3 (note that $t_1^3 = t_2^3 = t^{MFN}$). The optimal external tariff under the bilateral FTA is calculated as follows:

$$t^{ext} = t_3^1 = t_3^2 = \frac{1}{7}. \tag{1.8}$$

Equations (1.7) and (1.8) show that member countries voluntarily decrease the external tariff level relative to that under the MFN clause (i.e., $t^{ext} < t^{MFN}$), which is called *tariff complementarity effect*.[12] Article XXIV of GATT requires that, after forming RTAs, member countries should not raise tariff levels against nonmember countries, although the formation of RTAs is permitted. Equation (1.8) shows that this requirement is met.

Substituting $t_2^1 = t_1^2 = 0$, $t_1^3 = t_2^3 = t^{MFN}$ and Eq. (1.8) into Eq. (1.5), we can determine the social welfare under the bilateral FTA.

[12]See, Bagwell and Staige (1999). Saggi (2006) obtained the same result in a model similar to ours.

Table 1.2 Social welfare under bilateral FTA

	$W^i_{bilateral}$
Country 1	$\frac{5}{14d^1}+\frac{4}{49d^2}+\frac{1}{100d^3}$
Country 2	$\frac{4}{49d^1}+\frac{5}{14d^2}+\frac{1}{100d^3}$
Country 3	$\frac{5}{245d^1}+\frac{5}{245d^2}+\frac{98}{245d^3}$

From Tables 1.1 and 1.2, changes in the welfare of each country arising from the bilateral FTA are specified below:

$$W^1_{bilateral} - W^1 = -\frac{3}{70d^1} + \frac{351}{4900d^2} > 0 \text{ if } d^1 > \frac{70d^2}{117}, \tag{1.9a}$$

$$W^2_{bilateral} - W^2 = \frac{351}{4900d^1} - \frac{3}{70d^2} > 0 \text{ if } d^1 < \frac{117d^2}{70}, \tag{1.9b}$$

$$W^3_{bilateral} - W^3 = \frac{51(d^1+d^2)}{4900d^1d^2} > 0. \tag{1.9c}$$

From Eq. (1.9), we obtain the following result.

Proposition 1.1 *(i) A bilateral FTA can be formed when the market sizes of the negotiating countries are similar, that is,* $\frac{70d^j}{117} < d^i < \frac{117d^j}{70}$, *irrespective of the market size of the nonmember country. (ii) It also benefits the nonmember country and increases world welfare.*

The rationale underlying Proposition 1.1 is explained as follows. The formation of a bilateral FTA increases consumer surplus but decreases the member country's tariff revenue through the tariff elimination effect as well as the tariff complementarity effect on nonmember country (*allocation effect*). Under the assumptions in this chapter, the allocation effect is always positive; that is, an increase in consumer surplus exceeds a decrease in tariff revenue with the formation of an FTA.

It also decreases the profit in the home market through the tariff elimination effect as well as, indirectly, the tariff complementarity effect, while it directly increases the profit in the partner's market through the tariff elimination effect (*rent-shifting effect*). We should note that the bilateral FTA does not change the profit in the nonmember's market owing to segmented markets. The rent-shifting effect tends to be positive (negative) when the market size of the partner country is large (small) relative to their own market.[13] Therefore, when the partner's market size is sufficiently small relative to their own market, the rent-shifting effect is negative, and this negative effect dominates any positive allocation effect. That is why a bilateral FTA can be formed only when negotiating countries are similar.

[13]The rent-shifting effect becomes positive if $d^i > \frac{384}{351}d^j$ under $i-j$ FTA.

1.4 Analysis

As mentioned in Sect. 1.1, FTAs between similar countries were generally formed earlier, while FTAs between dissimilar countries have recently become more common. Thus, this section investigates whether the formation of a bilateral FTA between similar countries leads to MFT through overlapping regimes (Sect. 1.4.1) as well as through an expanding regime (Sect. 1.4.2).

As shown in Proposition 1.1, a bilateral FTA is formed when negotiating countries are similar. Hereafter, we maintain the following assumption for simplicity.

Assumption 1.1 *$d^1 = d^2 \equiv d$ and $0 < d^3 < 2d$.*

1.4.1 Overlapping Regime

1.4.1.1 Hub-and-Spoke System

Suppose that a bilateral FTA between countries 1 and 2 is already formed. Each country 1 and 2 becomes a hub country when it forms a bilateral FTA with country 3. The overlapping FTA is formed only when the resulting social welfare of each member country of new FTA exceeds the welfare under the status quo.

Suppose that countries 1 and 3 conclude a bilateral FTA.[14] In this case, hub country 1 imposes no tariff against both spoke countries 2 and 3. In contrast, neither spoke country 2 nor 3 imposes a tariff against hub country 1, while they set an external tariff against each other independently; the tariff level in this case is the same as the optimal external tariff under the bilateral FTA. (See Eq. (1.8).) Thus, the value of welfare for each country under a hub-and-spoke system is stated below.

From Tables 1.2 and 1.3, we derive the welfare change arising from the hub-and-spoke system, starting with a bilateral FTA.

$$W^1_{hub-spoke} - W^1_{bilateral} = -\frac{3}{224d} + \frac{351}{4900d^3} > 0, \tag{1.10a}$$

Table 1.3 Social welfare under hub-and-spoke system

	$W^i_{hub-spoke}$
Country 1	$\frac{667}{1568d} + \frac{4}{49d^3}$
Country 2	$\frac{47}{112d} + \frac{1}{49d^3}$
Country 3	$\frac{65}{784d} + \frac{5}{14d^3}$

[14]The same holds true for country 2 in the case where country 2 becomes a hub country because of symmetry between countries 1 and 2 (Assumption 1.1).

$$W^2_{hub-spoke} - W^2_{bilateral} = -\frac{15}{784d} + \frac{51}{4900d^3} > 0 \text{ if } d^3 < \frac{68}{125}d, \tag{1.10b}$$

$$W^S_{hub-spoke} - W^3_{bilateral} = \frac{33}{784d} - \frac{3}{70d^3} > 0 \text{ if } d^3 > \frac{56}{55}d, \tag{1.10c}$$

From Eq. (1.10), we obtain the following results.

Proposition 1.2 *(i) Suppose that a bilateral FTA between countries* 1 *and* 2 *is already formed. A hub-and-spoke system arises if* $\frac{56}{55}d < d^3$. *(ii) Under a hub-and-spoke system, the welfare of a nonmember of newly formed FTA, that is, country* 2*, is decreased.*

Proposition 1.2 states that a hub-and-spoke system arises if a nonmember country of an existing bilateral FTA is smaller in some degree than member countries. Let us consider the logic behind Proposition 1.2.

First, we discuss country 1. By being a hub country, country 1 eliminates tariffs against country 3; i.e., the tariff elimination effect also works in this case, but this tariff elimination effect is weaker than that caused by the formation of the first FTA under the MFN clause. This is because a tariff against country 3 has already reduced from $\frac{3}{10}$ to $\frac{1}{7}$ through the tariff complementarity effect of the bilateral FTA between countries 1 and 2. Therefore, the increase in consumer surplus and decrease in tariff revenue become small, and then the allocation effect is small while it remains positive. The tariff complementarity effect does not occur for the hub country because the tariff against country 2 was already eliminated by the FTA between countries 1 and 2. This means that the decrease in profit in the home market is lower than that in the MFN case because the tariff complementarity effect does not work. However, an increase in profit in a partner's market is the same through the tariff elimination effect on country 1. Therefore, the rent-shifting effect tends to be positive as compared with the original bilateral FTA case. Thus, being a hub country is always beneficial.

Next, we consider a spoke country 3, which is a nonmember of the first bilateral FTA. Before forming a hub-and-spoke FTA, country 3 imposes optimal tariff level t^{MFN} against both countries 1 and 2. By forming an FTA with country 1, country 3 eliminates tariffs against country 1 and reduces the tariff level against country 2. Thus, both the tariff elimination effect and tariff complementarity effect work. This means that the magnitude of allocation effect is the same as under formation of the first FTA. However, the rent-shifting effect on country 3 changes. As compared with a bilateral FTA under the MFN clause, the tariff elimination effect on country 3 falls because tariffs against country 3 were already lowered, although the tariff complementarity effect does not work on country 2 in country 1's market. Therefore, a nonmember country of the first FTA has an incentive to be a spoke country unless its market size is larger than that of the hub country.

Finally, we discuss another spoke country 2. The formation of a hub-and-spoke FTA does not change the allocation effect on country 2 but decreases the rent-shifting effect on country 2. A hub-and-spoke FTA decreases firm 2's profit in the hub country market because the tariff elimination effect on firm 3 works, while the tariff complementarity effect does not work on firm 2. This increases firm 2's profit in the market of country 3 through the tariff complementarity effect, but this effect is weakened by the tariff elimination effect on firm 1. That is why the formation of a hub-and-spoke FTA benefits country 2 only when the market size of country 3 is sufficiently large relative to that of the original member countries, i.e., $d^3 < \frac{68}{125}d$. This condition does not hold when both countries 1 and 3 have an incentive to form a hub-and-spoke FTA.

1.4.1.2 Spoke-Spoke FTA

We now consider whether two spoke countries, 2 and 3, have an incentive to form a bilateral FTA under a hub-and-spoke system. Under a hub-and-spoke system, the hub country 1 imposes no tariffs on both spoke countries, while the spoke countries impose external tariffs on each other, with the tariff levels being the same as shown in Eq. (1.8). If they form a bilateral spoke-spoke FTA, then MFT arises. Substituting $t_i^j = 0$ into (1.5), we obtain each country's welfare under free trade.

From Tables 1.3 and 1.4, the changes in the welfare of each country arising from the formation of a spoke-spoke FTA are specified below:

$$W_{FT}^1 - W_{hub-spoke}^1 = -\frac{15(d + d^3)}{784dd^3} < 0, \tag{1.11a}$$

$$W_{FT}^2 - W_{hub-spoke}^2 = \frac{3(22d - 7d^3)}{1568dd^3} > 0, \tag{1.11b}$$

$$W_{FT}^3 - W_{hub-spoke}^3 = \frac{3(22d^3 - 7d)}{1568dd^3} > 0 \text{ if } d^3 > \frac{7}{22}d. \tag{1.11c}$$

From here, we obtain the following results.

Proposition 1.3 *(i) Under a hub-and-spoke system, the formation of a spoke-spoke FTA is feasible if $d^3 < \frac{7}{22}d$, which in turn leads to MFT. (ii) A spoke-spoke FTA is detrimental to the hub country.*

The formation of a spoke-spoke FTA eliminates external tariffs on each spoke's firms in the spoke countries' markets; this leads to MFT. Let us consider a spoke country. By forming a spoke-spoke FTA, the tariffs between spoke countries reduce to zero. This tariff elimination effect indirectly worsens the effective cost advantage

Table 1.4 Social welfare under free trade

	W_{FT}^i
Country 1	$\frac{13}{32d} + \frac{2}{32d^3}$
Country 2	$\frac{13}{32d} + \frac{2}{32d^3}$
Country 3	$\frac{4}{32d} + \frac{11}{32d^3}$

in the home market against another spoke country's firm. Each spoke country's firm directly mitigates its cost disadvantage in another spoke country's market by tariff elimination. Then, the producer surplus in a relatively smaller spoke country is greater than that in another spoke country. Noting that the allocation effect is always positive, the spoke-spoke FTA benefits the spoke country unless its market size is sufficiently large relative to another spoke country.

For the original hub country, the formation of a spoke-spoke FTA eliminates the effective cost advantages in both spoke countries' markets and then decreases the profits of the hub-country firm in both spoke markets. Because the allocation effect does not work, the formation of a spoke-spoke FTA is always detrimental to the hub country.

1.4.2 Expanding Regime

In this subsection, we examine whether formation of a bilateral FTA leads to MFT in an expanding regime. From Proposition 1.1 and Assumption 1.1, we proceed to this discussion under the presumption that a bilateral FTA between symmetric countries 1 and 2 exists.

Given the existence of an FTA between countries 1 and 2, all governments negotiate for its expansion, which leads to MFT. Similar to the case of a bilateral FTA, each government sets its unilateral stance toward the expansion, and the FTA expands only when all governments agree with the negotiation. From Tables 1.2 and 1.4, the changes in welfare arising from an expansion of the bilateral FTA are mentioned as follows:

$$W^1_{FT} - W^1_{bilateral} = -\frac{51}{1568d} + \frac{21}{400d^3} > 0 \text{ if } d^3 < \frac{686}{425}d, \tag{1.12a}$$

$$W^2_{FT} - W^2_{bilateral} = -\frac{51}{1568d} + \frac{21}{400d^3} > 0 \text{ if } d^3 < \frac{686}{425}d, \tag{1.12b}$$

$$W^3_{FT} - W^3_{bilateral} = \frac{33}{392d} - \frac{9}{160d^3} > 0 \text{ if } d^3 > \frac{147}{220}d. \tag{1.12c}$$

Equation (1.12) indicates the following:

Proposition 1.4 *Expansion of a bilateral FTA through new membership is feasible if* $\frac{147}{220}d < d^3 < \frac{686}{425}d$.

Let us consider the logic behind Proposition 1.4. Expansion of a bilateral FTA through new membership gives a positive allocation effect for all countries. As d^3 increases given d (i.e., the relative market size of country 3 becomes small), the rent-shifting effect on both member countries of the bilateral FTA turns negative and then outweighs a positive allocation effect. In contrast, for country 3, the rent-shifting effect increases as d^3 increases because increases in profits in markets 1 and

2 are large relative to decreases in home market 3. Therefore, new member country 3 tends to have an incentive to join the bilateral FTA as its own market size is smaller, while neither member country of the original FTA has an incentive to accept a new member into the FTA if country 3 is small, i.e., $d^3 > \frac{686}{425}d$.

1.5 Feasibility of MFT Under Overlapping Regime and Expanding Regime

Now, we investigate whether a bilateral FTA acts as a building block or a stumbling block for MFT and how the difference in market sizes between member and nonmember countries affects the feasibility of MFT.

First, we confirm the feasibility of an MTA. From Tables 1.1 and 1.4, we observe the changes in welfare arising from a shift to MTA, as shown below:

$$W_{FT}^1 - W^1 = \frac{3(14d - d^3)}{800dd^3} > 0, \tag{1.13a}$$

$$W_{FT}^2 - W^2 = \frac{3(14d - d^3)}{800dd^3} > 0, \tag{1.13b}$$

$$W_{FT}^3 - W^3 = \frac{3(28d^3 - 15d)}{800dd^3} > 0 \text{ if } d^3 > \frac{15}{28}d. \tag{1.13c}$$

Proposition 1.5 *An MTA is negotiated if* $d^3 > \frac{15}{28}d$.

The formation of the MTA brings a positive allocation effect to all countries. Whether the rent-shifting effect becomes positive or negative depends on the differences of market sizes. For a relatively large country, the effect tends to be negative because a decrease in home market profit tends to be greater than an increase in profit in a smaller country market by forming an MTA. When the home market is sufficiently large (such as $d^3 > \frac{15}{28}d$), the rent-shifting effect is negative and outweighs the positive allocation effect. That is why a larger country may not have an incentive to form an MTA, while smaller countries always have an incentive to conclude it. Proposition 1.5 implies that an MTA is not feasible when one large country and two small countries exist.[15] This proposition may suggest that it is difficult to form an MTA because there are many small countries and a few large countries in the real world.

On the basis of Propositions 1.2, 1.3, 1.4, and 1.5, we establish the following:

Proposition 1.6 *Suppose that a bilateral FTA between symmetric countries is already formed. (i) A bilateral FTA becomes a stumbling block for MFT through an overlapping regime, while it acts as a building block for MFT through an expanding*

[15] Ornelas (2005b) showed similar results.

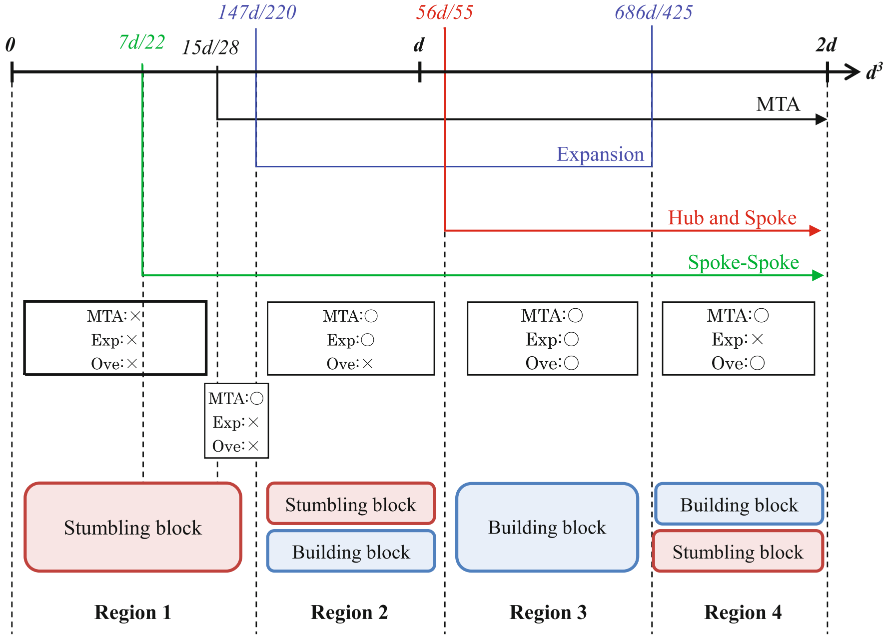


Fig. 1.3 Feasibility of MFT

regime when the market sizes of member and nonmember countries are quite similar. (ii) When the market size of a nonmember country is smaller than that of member countries, then an overlapping regime leads to MFT while an expanding regime may or may not. (iii) If the nonmember country of the original FTA is large, then an expanding regime may or may not achieve MFT, while an overlapping regime cannot. (iv) When the market size of a nonmember country is quite large as compared with member countries, MFT never arises through an overlapping regime, an expanding regime, or a negotiation of an MTA.

Figure 1.3 summarizes these results. In region 1, MFT never arises, while both overlapping and expanding regimes achieve MFT in region 3. In region 2, an expanding regime acts as a stumbling block, while an overlapping regime serves as a building block. In contrast, an overlapping regime leads to MFT, but an expanding regime cannot in region 4.

Now, let us consider the role of market asymmetry on the feasibility of the issue. The above results show that, when countries are similar, an expanding regime always achieves MFT, but an overlapping regime may or may not. In particular, they show that, if all countries are symmetric, an expanding regime acts as a building block, although an overlapping regime serves as a stumbling block. These results contrast to those obtained by Nomura et al. (2013), who investigated similar issues in a situation where all three countries differ with respective to market size. Nomura et al. (2013) showed that overlapping FTAs lead to MFT only when two larger countries form a bilateral FTA initially, and a bilateral FTA is never expanded.[16] These results indicate that whether and in which regime MFT is realized depend on the difference in market size, not only between member countries of a bilateral FTA but also between member and nonmember countries.

In the real world, FTAs among developed countries were formed, and then FTAs among developed and developing countries have been increasing. Our chapter shows that, if larger countries form a bilateral FTA, either an overlapping or an expanding regime leads to MFT. This implies that the formation of a bilateral FTA can serve as a building block for MFT, although this is an exception to the nondiscrimination rule under GATT/WTO.

1.6 Concluding Remarks

This chapter has investigated the feasibility of MFT through both overlapping and expanding regimes in the presence of market asymmetry between member and nonmember countries of an existing bilateral FTA. It has determined whether the bilateral FTA leads to MFT in a three-country model, wherein each country has a local firm and a domestic market. We summarize the main conclusions as follows. Suppose that a bilateral FTA between symmetric countries is already formed. (i) A bilateral FTA becomes a stumbling block for MFT through an overlapping regime, while it acts as a building block for MFT through an expanding regime when the market sizes of member and nonmember countries are quite similar. (ii) When the market size of a nonmember country is smaller than that of member countries, then an overlapping regime leads to MFT, while an expanding regime may or may not. (iii) If the nonmember country of the original FTA is large, then an expanding regime may achieve MFT, while an overlapping regime cannot. (iv) When the market size of a nonmember country is quite large as compared with member countries, MFT never arises through an overlapping regime, expanding regime, or negotiation of an MTA.

Future studies can extend this chapter in several directions. Our main conclusions are derived under the assumption of symmetry between member countries. It is interesting to construct a model where all countries can be symmetric as well as asymmetric. In this chapter, we have not considered lobbying practices, which is a potential extension of the model.[17] It would be interesting to introduce cost differences among firms and multiple numbers of firms and/or countries.

[16]We should note that our assumption of market asymmetry is different from that in Nomura et al. (2013), which cannot consider the situation where all countries are symmetric.

[17]For example, Endoh (2006), Krishna (1998), Mukunoki and Tachi (2006), and Ornelas (2005b) considered the effect of lobbying practices on RTAs.

Acknowledgements This work was supported by Grants-in-Aid for Scientific Research (no. 23530303, 26380340, and 26380318). All remaining errors are ours.

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Chapter 2
The Feasibility of Multilateral Free Trade and Mode of Competition: Stackelberg Versus Cournot Competitions

Ryoichi Nomura

Abstract This chapter investigates how mode of competition affects the feasibility of multilateral free trade (MFT) through formation of a bilateral free trade agreement (FTA) by comparing Stackelberg competition with Cournot competition in a three-country model with asymmetric markets. Our main conclusion is as follows: As compared with Cournot competition, Stackelberg competition lowers the feasibility of a bilateral FTA as well as the attainability of MFT.

Keywords Free trade agreement • Multilateral free trade • Stackelberg competition

2.1 Introduction

Recently, a proliferation of regional trade agreements (RTAs) has come under observation (WTO, 2015a,b). As Fiorentino et al. (2009) pointed out, one feature of recent RTAs is an overlapping formation of bilateral free trade agreements (FTAs) among different countries. In keeping with this feature, several articles have been developed to the study of the feasibility of multilateral free trade (MFT) through the formation of FTAs (Krishna, 1998; Ornelas, 2005a,b; Saggi, 2006). While these studies address only the expansion of FTAs through the addition of new members, Mukunoki and Tachi (2006) and Nomura et al. (2013) also consider the formation of overlapping FTAs.

These previous studies commonly assumed that firms compete *à la* Cournot. However, in reality, it is not necessarily the case that firms compete Cournot fashion. Stackelberg model is one of the most widely used model for analyzing firms' strategic behavior. For example, Dastigar (2004) compared the equilibrium configuration of the quantity Stackelberg model with the price Stackelberg model.

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*, New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_2

Huck et al. (2001) showed that the profitability of merger also depends on the market structure and on the involved firms' strategic power in the Stackelberg model. Etro (2008) investigated a general characterization of Stackelberg equilibrium with endogenous entry of followers. Liu (2005) examined how the demand uncertainty affects the first-mover advantage in the Stackelberg model. Amir (1999), Anderson and Engers (1992), and Julien (2011) compared Cournot model with Stackelberg model.

These researches showed that the order of moves changes firms' behavior. Consequently, it affects the decision of the governments for trade policies as a result. Surprisingly, however, there is little literature dealing with whether the overlapping formation of FTAs leads to MFT under Stackelberg competition, and there are no result, to our knowledge, which compares the feasibility of MFT through overlapping formation of FTAs under Cournot competition and Stackelberg competition.

This drives us to the question of how the mode of competition affects the feasibility of MFT through the formation of FTAs. In this chapter, we introduce Stackelberg competition into Nomura et al. (2013), who investigated the feasibility of MFT through the formation of bilateral FTAs in a three-country model with asymmetric markets under Cournot competition. We obtain the following results: Compared with Cournot competition, Stackelberg competition lowers a bilateral FTA's feasibility as well as the attainability of MFT.

The rest of this chapter is organized as follows: Section 2.2 presents our model. Section 2.3 shows the preliminary results under Stackelberg competition. In Sect. 2.4, we compare the results under Stackelberg competition with those under Cournot. Section 2.5 concludes the chapter.

2.2 The Model

Consider a world economy with three countries. Each country has a single local firm and a domestic market. We refer to these countries according to their market sizes; that is, the country with the largest market is called a "large country" (L), that with a medium-sized market "medium country" (M), and that with the smallest market "small country" (S). We assume that the markets are segmented. The demand function of market i ($i = L, M, S$) is given by the following:

$$P^i = 1 - d^i Q^i, \tag{2.1}$$

where $Q^i = q_L^i + q_M^i + q_S^i$ is the total quantity supplied to market i and q_j^i is the quantity supplied by the firm in country j to market i. We assume that $d^S \equiv 2 > d^M > d^L \equiv 1$. We denote d^M by d. The market size of the medium country is inversely related to d. Each government i imposes a specific tariff t_j^i on imports from country j. All firms compete *à la* Stackelberg in all markets. Without loss of generality, let a home firm in each market be a leader and two foreign firms be followers. We assume that firms have an identical cost function and normalize the production cost to zero. Further, there are no transportation costs among the markets. The profits of firm j in market i are given by

$$\pi_j^i = (P^i - t_j^i)q_j^i. \tag{2.2}$$

The welfare function of country i is the sum of consumer surplus, producer surplus of its local firm, and the tariff revenue, represented by

$$W^i = \frac{(1 - P^i)Q^i}{2} + (\pi_i^L + \pi_i^M + \pi_i^S) + t_j^i q_j^i + t_k^i q_k^i. \tag{2.3}$$

In the initial situation, no FTA is formed. Therefore, each government sets its import tariff independently. We assume that only one FTA is negotiated at once, and no FTA is dissolved after its formation. Governments engaged in the present negotiation are interested in knowing whether the formation of an FTA improves its national welfare, as compared with the status quo. However, they are not concerned about how the present FTA influences future negotiations over other FTAs.

In the first round, two of the three governments negotiate to form a bilateral FTA. If an FTA is not formed, no subsequent negotiations occur. Now, suppose that one bilateral FTA is formed. Given that this situation is status quo, another negotiation will also be conducted. There are two possible paths to MFT after the formation of a bilateral FTA: (i) When both members of the existing bilateral FTA agree to accept the nonmember country as a new member, MFT is realized (*expanding regime*). (ii) When one of the bilateral FTA members forms another FTA with a nonmember country, a hub-and-spoke system arises. Under the hub-and-spoke system, two spoke countries can negotiate an FTA (spoke-spoke FTA), which leads to MFT (*overlapping regime)*. Therefore, two rounds occur in an expanding regime, whereas three rounds occur in an overlapping regime. Figure 2.1 shows the time line, while Figs. 2.2 and 2.3 illustrate the possible paths to MFT under both expanding and overlapping regimes.

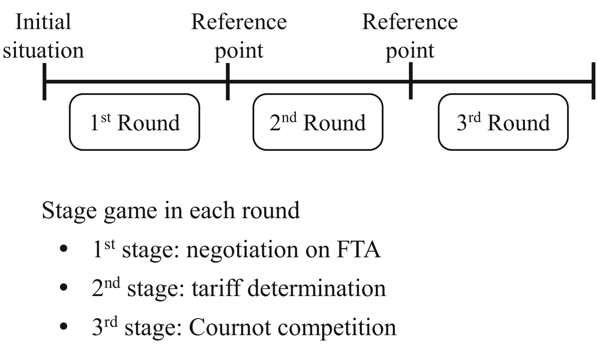

Fig. 2.1 Time line

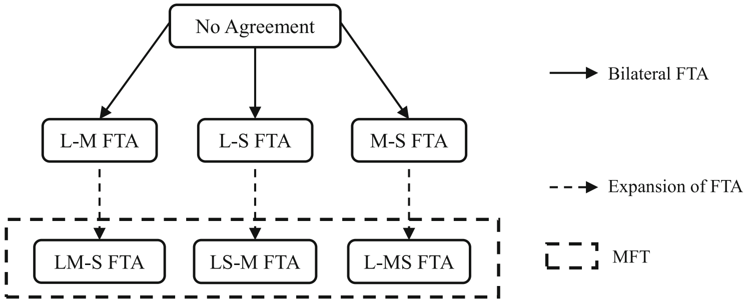

Fig. 2.2 Possible paths to MFT under expansion regime

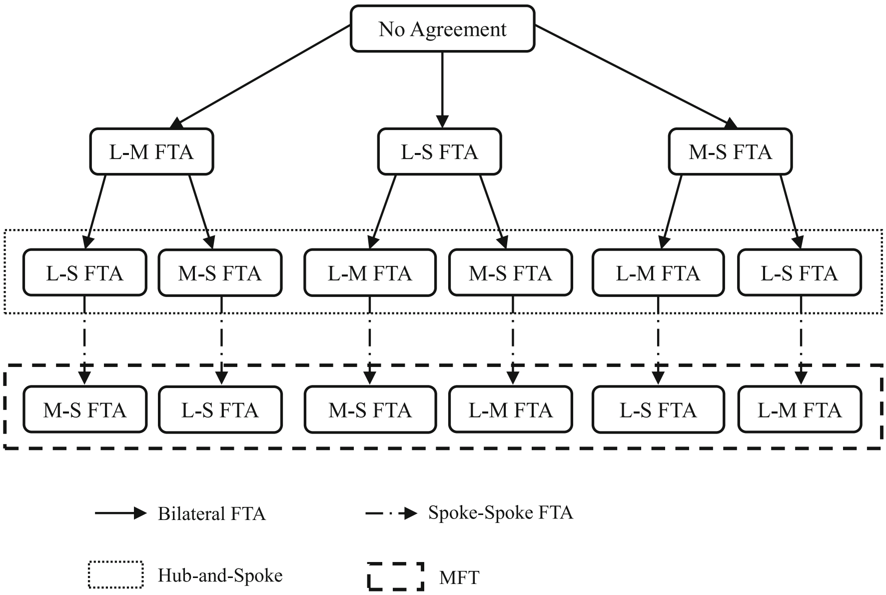

Fig. 2.3 Possible paths to MFT

Each round proceeds as shown in the following four-stage game.[1] In the first stage, governments negotiate an FTA. Given the initial situation (pattern of existing FTAs), the countries engage in FTA negotiation. These countries then choose their unilateral stance on the FTA, that is, whether to participate or not. Each government chooses to participate only when the resulting social welfare is higher under the newly formed FTA than under the status quo. The FTA will be formed when all the governments involved in the negotiation choose to participate. Otherwise, no FTA is formed, and the status quo continues. If the governments fail to form

[1]The structure of this game is the same that in Chap. 1 as well as Nomura et al. (2013).

any FTA, no further negotiation over the FTA occurs. In the second stage, all governments set their import tariff so as to maximize social welfare independently and simultaneously. When an FTA is formed, the governments of member countries do not impose any internal tariff; they only set an external tariff. In the third stage, a leader local firm selects its output in each market, given the tariff levels set by the governments in the previous stage, and two foreign follower firms select their outputs simultaneously in each market in the fourth stage. We solve this game in each round by backward induction.

2.3 Analysis

In this section, we first consider the outcome in the initial situation where no FTA exists (Sect. 2.3.1). We then investigate whether the formation of a bilateral FTA leads to MFT in an overlapping regime (Sect. 2.3.2) and in an expanding regime (Sect. 2.3.3).

2.3.1 Initial Situation: No FTA

First, we consider the outcome in the initial situation where no FTA is formed. That is, each government sets its tariff rate independently.

In the fourth stage, two foreign follower firms choose their level of output simultaneously in each market, given a leader firm's output and tariff level. Note that we can treat each market separately because the marginal costs are constant (zero). From Eqs. (2.1) and (2.2), given a leader firm i's output, each follower firm j in market i chooses its quantity as follows:

$$q_j^i = \frac{1}{3d^i}\left(1 - q_i^i - 2t_j^i + t_k^i\right). \tag{2.4}$$

In the third stage, a leader firm chooses its quantity q_i^i to maximize its profits given the tariff level, anticipating the effects its choice will have on the followers' subsequent decisions. The profit-maximizing quantity is given by

$$q_i^i = \frac{1}{2d^i}\left(1 + t_j^i + t_k^i\right). \tag{2.5}$$

Hence, the followers choose

$$q_j^i = \frac{1}{6d^i}\left(1 - 5t_j^i + t_k^i\right). \tag{2.6}$$

Table 2.1 Social welfare without an FTA

	W^i
Country L	$\frac{2+1089d}{2312d}$
Country M	$\frac{3+1088d}{2312d}$
Country S	$\frac{1+273d}{1156d}$

In the second stage, each government determines the tariff level so as to maximize national welfare. From Eqs. (2.1), (2.2), (2.3), (2.5), and (2.6), we have the equilibrium tariff rate when no FTA is formed:

$$t^* = (t_j^i)^* = \frac{7}{34}, \quad i, j = L, M, S. \tag{2.7}$$

Note that none of the governments do anything in the first stage because there is no FTA in the initial situation.

Substituting (2.1), (2.2), (2.5), (2.6), and (2.7) into (2.3), we obtain social welfare as shown in Table 2.1. Thus, the larger the market size, the larger the resulting welfare.

2.3.2 Overlapping Regime

In this subsection, we investigate the feasibility of a bilateral FTA as well as overlapping FTAs.

2.3.2.1 The First-Round Negotiation: Bilateral FTA

We now examine three possible bilateral FTAs that can occur in the first-round negotiation.

Large-Medium FTA (L-M FTA)

Suppose that an FTA between countries L and M is formed. In this case, governments L and M do not set any internal tariffs ($t_L^M = t_M^L = 0$) and impose an external tariff against nonmember country S, so as to maximize their own national welfare. In contrast, government S does not change the tariff level on imports from countries L and M. Thus, the formation of an L-M FTA does not change the quantity supplied to market S (Note that $t_L^S = t_M^S = t^*$). The optimal external tariffs under an L-M FTA are calculated as follows:

$$t_S^L = t_S^M = \frac{7}{53} \equiv t_{LM}. \tag{2.8}$$

Table 2.2 Social welfare under an L-M FTA

	W_{LM}^i
Country L	$\frac{54385}{122536}+\frac{100}{2809d}$
Country M	$\frac{234009}{6494408}+\frac{47}{106d}$
Country S	$\frac{11389}{47753}+\frac{9}{2809d}$

From $t_L^M = t_M^L = 0$, $t_L^S = t_M^S = t^*$, and (2.8), we can determine the social welfare under the L-M FTA.

From Tables 2.1 and 2.2, changes in the welfare of each country arising from the L-M FTA are specified below:

$$W_{LM}^L - W^L = \frac{7(-12614 + \frac{16113}{d})}{3247204} > 0 \text{ if } d < \frac{16113}{12614} \equiv d_{LM} \approx 1.27, \tag{2.9a}$$

$$W_{LM}^M - W^M = \frac{7(16113 - \frac{12614}{d})}{3247204} > 0, \tag{2.9b}$$

$$W_{LM}^S - W^S = \frac{7595(1+d)}{3247204d} > 0. \tag{2.9c}$$

From equation (2.9), we obtain the following result:

Lemma 2.1 *(i) An L-M FTA is formed if $d < d_{LM}$. (ii) An L-M FTA also benefits nonmember country S.*

Medium-Small FTA (M-S FTA)

Next, we consider the feasibility of an M-S FTA. Following the same argument for an L-M FTA, the optimal external tariff under an M-S FTA is

$$t_L^M = t_L^S = \frac{7}{53} \equiv t_{MS}. \tag{2.10}$$

From $t_S^M = t_M^S = 0$, $t_M^L = t_S^L = t^*$, and (2.10), we derive social welfare under an M-S FTA as follows:

From Tables 2.1 and 2.3, the welfare changes of each country arising from the M-S FTA are specified below:

$$W_{MS}^L - W^L = \frac{7595(2+d)}{6494408d} > 0, \tag{2.11a}$$

$$W_{MS}^M - W^M = \frac{7(16113 - \frac{25228}{d})}{6494408} \text{ if } d > \frac{25228}{16113} \equiv d_{MS} \approx 1.56, \tag{2.11b}$$

$$W_{MS}^S - W^S = \frac{7(16113 - 6307d)}{3247204d} > 0. \tag{2.11c}$$

Table 2.3 Social welfare under an M-S FTA

	W^i_{MS}
Country L	$\frac{45097}{95506}+\frac{9}{2809d}$
Country M	$\frac{60609}{3247204}+\frac{47}{106d}$
Country S	$\frac{3409}{15317}+\frac{100}{2089d}$

Table 2.4 Social welfare under an L-S FTA

	W^i_{LS}
Country L	$\frac{2591}{5618}+\frac{1}{1156d}$
Country M	$\frac{27}{5618}+\frac{8}{17d}$
Country S	$\frac{2891}{11236}+\frac{1}{1156d}$

From (2.11), we obtain the following result:

Lemma 2.2 *(i) An M-S FTA is formed if $d > d_{MS}$. (ii) An M-S FTA also benefits nonmember country L.*

Large-Small FTA (L-S FTA)

Finally, we examine whether an L-S FTA is formed. The optimal external tariff under an L-S FTA is calculated as follows:

$$t^L_M = t^S_M = \frac{7}{53} \equiv t_{LS}. \tag{2.12}$$

From $t^L_S = t^S_L = 0$, $t^M_L = t^M_S = t^*$, and (2.12), the values of social welfare under an L-S FTA are obtained as shown in Table 2.4.

From Tables 2.1 and 2.4, changes in the welfare of each country arising from the L-S FTA are specified below:

$$W^L_{LS} - W^L = -\frac{63805}{6494408} < 0, \tag{2.13a}$$

$$W^M_{LS} - W^M = \frac{22785}{6494408} > 0, \tag{2.13b}$$

$$W^S_{LS} - W^S = \frac{34321}{1623602} > 0. \tag{2.13c}$$

From (2.13), we derive the following:

Lemma 2.3 *An L-S FTA is not formed.*

From lemmas 2.1 through 2.3, we obtain the following results:

Proposition 2.1 *(i) A bilateral FTA is formed only when the market sizes of the negotiating countries are similar to some extent. (ii) If a bilateral FTA is formed, it benefits the nonmember country and increases world welfare.*

Table 2.5 Social welfare under overlapping FTAs [1]

	W^i_{LM-LS}	W^i_{LM-MS}
Country L	$\frac{90679}{202248}+\frac{100}{2809d}$	$\frac{1250}{2809}+\frac{1}{36d}$
Country M	$\frac{2971}{101124}+\frac{47}{106d}$	$\frac{150}{2809}+\frac{31}{72d}$
Country S	$\frac{119}{477}+\frac{9}{2809d}$	$\frac{2527}{11236}+\frac{1}{36d}$

The intuition underlying Proposition 2.1 is explained as follows. The formation of a bilateral FTA eliminates initial internal tariffs and reduces external tariffs from $\frac{7}{34}$ to $\frac{7}{53}$, as shown in Eqs. (2.7), (2.8), (2.10), and (2.12). The formation of a bilateral FTA raises consumer surplus but lowers tariff revenue. The effect on producer surplus is ambiguous. The profit of home firm i in the domestic market i decreases, whereas its profit in the market of the partner country increases, and its profit in the market of the nonmember country remains unchanged. If the size of the home market is greater than that of the partner country's market, the loss in profits in the home market outweighs the gain in profits in the partner's market. In this case, the formation of a bilateral FTA may harm the home country's welfare, although it raises the partner country's welfare. When the market sizes differ between negotiating countries, the negotiation fails because the larger country has no incentive to form an FTA. Therefore, L-M and M-S FTAs can be formed, but an L-S FTA is not formed.

2.3.2.2 Hub-and-Spoke System

Suppose that an L-M FTA is already formed. Each country L and M becomes a hub country when it forms a bilateral FTA with country S. The overlapping FTA, L-S (M-S) FTA, is formed only when the resulting social welfare of each country, L (M) and S, exceeds the welfare under the status quo, that is, the welfare under the L-M FTA. If countries L (M) and S form a bilateral FTA, they eliminate internal tariffs between them. In this case, a hub country L (M) imposes no tariff against both spoke countries M (L) and S. In contrast, neither spoke country, M (L) and S, imposes a tariff against the hub country L (M), while they set an external tariff against each other independently; the tariff level in this case is the same as the optimal external tariff under the bilateral FTA (See Eqs. (2.8), (2.10), and (2.12)). Thus, the welfare values of each country under a hub-and-spoke system are stated in Table 2.5.

From Tables 2.2 and 2.5, we derive the welfare change arising from the formation of overlapping FTAs, starting from an existing L-M FTA.

[1] L-S FTA

$$W^L_{LM-LS}-W^L_{LM}=\frac{132293}{29224836}>0, \tag{2.14a}$$

$$W^M_{LM-LS}-W^M_{LM}=-\frac{388843}{58449672}<0, \tag{2.14b}$$

$$W^S_{LM-LS}-W^S_{LM}=\frac{4718}{429777}>0, \tag{2.14c}$$

[2] M-S FTA

$$W^L_{LM-MS} - W^L_{LM} = \frac{7(9765d - 65314)}{58449672d} < 0, \tag{2.15a}$$

$$W^M_{LM-MS} - W^M_{LM} = \frac{7(145017d - 107219)}{58449672d} > 0, \tag{2.15b}$$

$$W^S_{LM-MS} - W^S_{LM} = \frac{7(6035 - 3339d)}{1719108d} > 0 \text{ if } d < \frac{6035}{3339} \approx 1.807. \tag{2.15c}$$

Noting that $d_{LM} < 6035/3339$, (2.14), and (2.15), we obtain the following result:

Lemma 2.4 *Suppose that an L-M FTA is already formed. Both countries L and M can form overlapping FTAs with country S.*

Starting from an existing M-S FTA, either country M or S becomes a hub country when each of them forms a bilateral FTA with country L. Following the same argument for an overlapping FTA under an L-M FTA, the welfare of each country under a hub-and-spoke system is specified below.

From Tables 2.3 and 2.6, we find that the welfare change arising from the formation of overlapping FTAs under an M-S FTA can be expressed as follows:

[1] L-M FTA

$$W^L_{MS-LM} - W^L_{MS} = \frac{7(6035 - 6678d)}{1719108d} < 0, \tag{2.16a}$$

$$W^M_{MS-LM} - W^M_{MS} = \frac{7(-107219 + 290034d)}{58449672d} > 0, \tag{2.16b}$$

$$W^S_{MS-LM} - W^S_{MS} = \frac{7(-32657 + 9765d)}{29224836d} < 0, \tag{2.16c}$$

[2] L-S FTA

$$W^L_{MS-LS} - W^L_{MS} = -\frac{51247}{3438216} < 0, \tag{2.17a}$$

$$W^L_{MS-LS} - W^L_{MS} = -\frac{91889}{58449672} < 0, \tag{2.17b}$$

$$W^L_{MS-LS} - W^L_{MS} = \frac{3309943}{116899344} > 0. \tag{2.17c}$$

Table 2.6 Social welfare under overlapping FTAs [2]

	W^i_{MS-LM}	W^i_{MS-LS}
Country L	$\frac{1250}{2809} + \frac{1}{36d}$	$\frac{1745}{3816} + \frac{9}{2809d}$
Country M	$\frac{150}{2809} + \frac{31}{72d}$	$\frac{3457}{202248} + \frac{47}{106d}$
Country S	$\frac{2527}{11236} + \frac{1}{36d}$	$\frac{101479}{404496} + \frac{100}{2809d}$

Equations (2.16) and (2.17) state that nonmember country L has no incentive to form a bilateral FTA with either country M or S after the formation of an M-S FTA. Thus, we can derive the following:

Lemma 2.5 *Suppose that an M-S FTA is already formed. No overlapping FTA can then be formed.*

Note that we do not need to examine the overlapping LS-LM and LS-MS FTAs because the L-S FTA cannot be formed initially.

From lemmas 2.4 and 2.5, we obtain the following result.

Proposition 2.2 *Overlapping FTAs occur under an L-M FTA only.*

2.3.2.3 Spoke-Spoke FTA

We now investigate whether two spoke countries have an incentive to form a bilateral spoke-spoke FTA under a hub-and-spoke system. If they form a bilateral spoke-spoke FTA, MFT arises. Each country's welfare under free trade is as follows.

From Tables 2.5 and 2.7, the changes in the welfare of each country arising from the formation of a spoke-spoke FTA are specified below:

[1] M-S FTA

$$W_{FT}^{L} - W_{LM-LS}^{L} = -\frac{791(d+2)}{202248d} < 0, \tag{2.18a}$$

$$W_{FT}^{M} - W_{LM-LS}^{M} = \frac{7(355d-371)}{202248d} > 0 \text{ if } d > \frac{371}{355} \approx 1.045, \tag{2.18b}$$

$$W_{FT}^{S} - W_{LM-LS}^{S} = \frac{7(\frac{1420}{d} - 371)}{404496d} > 0, \tag{2.18c}$$

[2] L-S FTA

$$W_{FT}^{L} - W_{LM-MS}^{L} = -\frac{14}{25281} < 0, \tag{2.19a}$$

$$W_{FT}^{M} - W_{LM-MS}^{M} = -\frac{791}{67416} < 0, \tag{2.19b}$$

$$W_{FT}^{S} - W_{LM-MS}^{S} = \frac{7343}{404496} > 0. \tag{2.19c}$$

Table 2.7 Social welfare under free trade

	W_{FT}^{i}
Country L	$\frac{4}{9} + \frac{1}{36d}$
Country M	$\frac{1}{24} + \frac{1}{12d}$
Country S	$\frac{5}{72} + \frac{1}{36d}$

From the above equations, we obtain the following results:

Proposition 2.3 *(i) Under LM-LS FTAs, an M-S FTA is feasible if* $d > \frac{371}{355}$*, which in turn leads to MFT. (ii) Under LM-MS FTAs, the formation of a spoke-spoke FTA cannot be formed. (iii) A feasible spoke-spoke FTA is detrimental to the hub country.*

Let us consider an intuition behind Proposition 2.3. Suppose that LM-LS FTAs exist. Country M does not have an incentive to form a spoke-spoke FTA with country S if $d < \frac{371}{355}$, that is, the market size of country M is quite large, while country S always has an incentive to do so. Likewise, under LM-MS FTAs, country L has no incentive to form a spoke-spoke FTA with country S. In sum, under a hub-and-spoke system, if a country has a quite large market as compared with the negotiating country, then the country has no incentive to form a spoke-spoke FTA. The formation of a spoke-spoke FTA eliminates an effective cost advantage in the home market as well as an effective cost disadvantage in the other spoke country's market, and it then reduces profits in the home market and increases profits in the other spoke country's market. Under Stackelberg competition, unlike Cournot competition, a leader home firm has a larger market share, and a follower firm has a smaller market share in each market. This property enlarges the decrease in profit in the home market by the formation of a spoke-spoke FTA and lessens the increase in profit in the partner's market. Thus, a country with a quite large market has no incentive to form a spoke-spoke FTA even if an increase in consumer surplus exceeds a decrease in tariff revenue.

2.3.3 Expanding Regime

In this subsection, we examine whether the formation of a bilateral FTA leads to MFT in an expanding regime.

2.3.3.1 Bilateral FTA

In an expanding regime, the initial situation, wherein a bilateral FTA can be formed, is the same as that in an overlapping regime (Sect. 2.3.2.1). We restate the results:

Remark 2.1 (i) An L-M FTA is formed if $d < d_{LM}$. (ii) An M-S FTA is formed if $d > d_{MS}$. (iii) An L-S FTA is not formed.

2.3.3.2 Expansion of Bilateral FTA

Now, we consider the expansion of a bilateral FTA through new membership. We first examine the expansion of an L-M FTA. Given the existence of an L-M FTA, all governments negotiate for its expansion, which leads to MFT. Similar to the case of a bilateral FTA, each government decides its unilateral stance on the expansion, and the FTA expands only when all governments agree with the negotiation. From Tables 2.2 and 2.7, the changes in welfare arising from an expansion of the L-M FTA are mentioned as follows:

$$W_{FT}^{L} - W_{LM}^{L} = \frac{7(5141d - 65314)}{58449672d} < 0, \tag{2.20a}$$

$$W_{FT}^{M} - W_{LM}^{M} = \frac{7(47046d - 107219)}{58449672d} < 0, \tag{2.20b}$$

$$W_{FT}^{S} - W_{LM}^{S} = \frac{7(4477d + 24140)}{6876432d} > 0. \tag{2.20c}$$

Equation (2.20) shows that the expansion of the L-M FTA does not occur.

Second, we consider the expansion of an M-S FTA. From Tables 2.3 and 2.7, the changes in welfare arising from an expansion of the M-S FTA are mentioned below:

$$W_{FT}^{L} - W_{MS}^{L} = \frac{7(6035 - 6814d)}{1719108d} < 0, \tag{2.21a}$$

$$W_{FT}^{M} - W_{MS}^{M} = \frac{7(-107219 + 192063d)}{58449672d} > 0, \tag{2.21b}$$

$$W_{FT}^{S} - W_{MS}^{S} = \frac{7(-130628 + 342221d))}{116899344d} > 0. \tag{2.21c}$$

Equation (2.21) shows that an expansion of the M-S FTA is not realized. We summarize these arguments as follows:

Proposition 2.4 *An expansion of a bilateral FTA through new membership is not feasible.*

Let us consider the intuition behind Proposition 2.4. If a bilateral FTA expands, the elimination of external tariffs increases consumer surplus and eliminates tariff revenue in all countries. Profits of firms in the original FTA member countries decline in both the home and partner's markets, while profits in the new member's market increase.

Let us consider expansion of an L-M FTA. Before the expansion, country L imposes an external tariff on nonmember country S only, which is already reduced by the formation of the L-M FTA. An expansion reduces π_L^L largely through tariff elimination because the leader firm's market share is large. However, changes in π_L^M and π_L^S are small because firm L is a follower in both markets M and S. In addition, changes in CS^L and TR^L are also small because of tariff elimination and tariff reduction by the formation of the L-M FTA. This is why country L has no incentive to expand an L-M FTA through new membership.

Next, we consider expansion of an M-S FTA. In this case, nonmember country L imposes t^* on firms in both countries M and S before the expansion. To participate an M-S FTA, country L has to eliminate those import tariffs. It reduces π_L^L drastically and eliminates TR^L. On the other hand, increases in π_L^M and π_L^S are small because the market shares of firm L in both markets are small and tariff level on firm L under the M-S FTA is already lowered. Although CS^L increases, losses of profits in the home market and tariff revenue dominate increased profits in two foreign markets and consumer surplus. Therefore, country L has no incentive to join the M-S FTA.

Proposition 2.4 indicates that formation of a bilateral FTA cannot achieve MFT through expansion of the FTA under Stackelberg competition.

2.4 Comparison of Stackelberg with Cournot Competition

Finally, we compare the result under Stackelberg competition with that under Cournot. First, we examine the feasibility of a bilateral FTA. Figure 2.4 summarizes the result under Cournot competition (shown in Proposition 1 in Nomura et al. (2013)). Figure 2.5, on the other hand, shows the result under Stackelberg competition.

Proposition 2.5 *(i) Stackelberg competition reduces the feasibility of a bilateral FTA as compared with Cournot competition. (ii) Under Stackelberg competition, no kind of FTA can be concluded if* $d^{LM} < d < d^{MS}$.

Stackelberg competition makes the market share of a home firm (each foreign firm) large (small) as compared with Cournot competition because a home firm (foreign firm) is a leader (a follower). Thus, a decrease in profits in a home market by formation of a bilateral FTA becomes larger, and an increase in profits in both foreign markets becomes smaller than those under Cournot competition. Thus, a country with a larger market tends to have no incentive to form a bilateral FTA. As

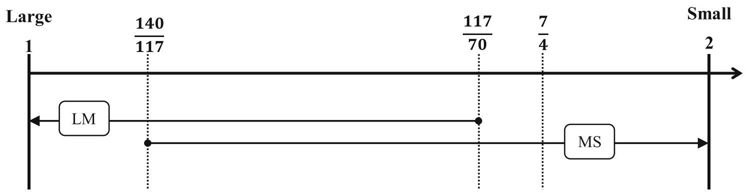

Fig. 2.4 Feasible condition of FTA under Cournot competition

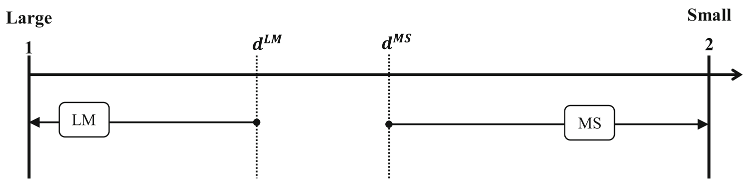

Fig. 2.5 Feasible condition of FTA under Stackelberg competition

a result, when market sizes of all countries are different, a bilateral FTA cannot be formed under Stackelberg competition, although at least one kind of bilateral FTA is formed under Cournot competition.

Next, we investigate whether formation of a bilateral FTA acts as a building block for MFT under Stackelberg competition. Figure 2.6 shows attainable paths to MFT under Cournot competition (shown in Nomura et al. 2013), whereas Fig. 2.7 shows that under Stackelberg competition.

From Propositions 2.3, 2.4, Figs. 2.5, and 2.7, we obtain the following results:

Proposition 2.6 *Suppose that firms compete à la Stackelberg. Formation of an L-M FTA acts as a building block via overlapping FTAs only when* $1.045 < d < d^{LM}$. *Otherwise, MFT is never realized under either overlapping or expanding regimes.*

Figure 2.8 summarizes Propositions 2.5 and 2.6. In region 1, MFT is not realized through both regimes, although an L-M FTA can be formed. In region 2, only an L-M FTA acts as a building block through an overlapping regime. Any kind of FTA can be formed in region 3. In region 4, MFT is not achieved, although an M-S FTA can be negotiated (partial liberalization).

Let us consider the intuition behind Proposition 2.6. An L-M FTA can act as a building block for MFT only when bilateral FTAs are formed in the order corresponding to L-M, L-S, and M-S FTAs. Consider country *L*. The formation of an L-M FTA lowers the external tariff on country *S*. This tariff complementarity effect reduces the loss of profits of home firm *L* in the home market by the formation of an L-S FTA under an L-M FTA. However, the increased profits of home firm *L* in market *S* are unchanged because the tariff levied by country *S* remains at the same level if an L-M FTA is formed. That is why country *L* has an incentive to form an L-S FTA under an existing L-M FTA, although country *L* has no incentive to form

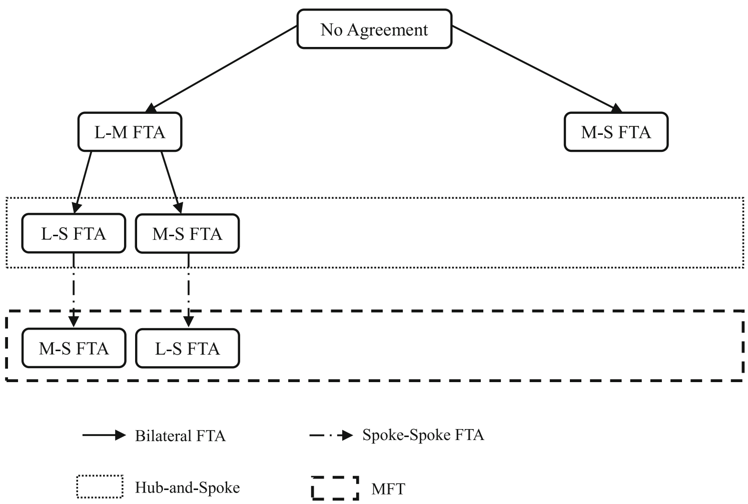

Fig. 2.6 Attainable paths under Cournot competition

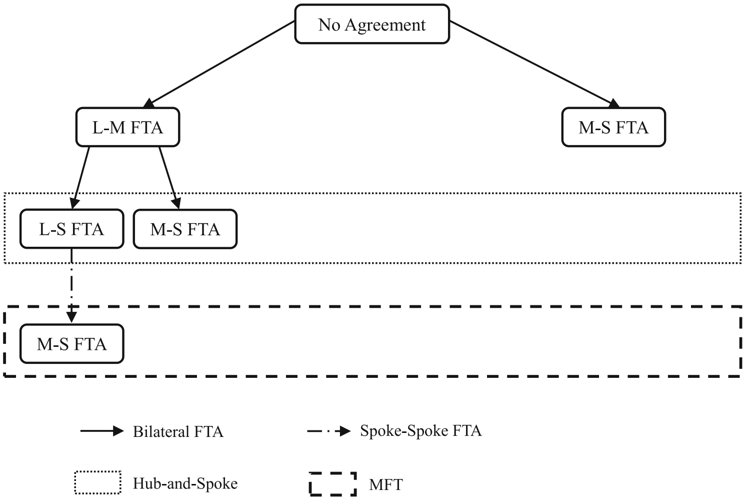

Fig. 2.7 Attainable paths under Stackelberg competition

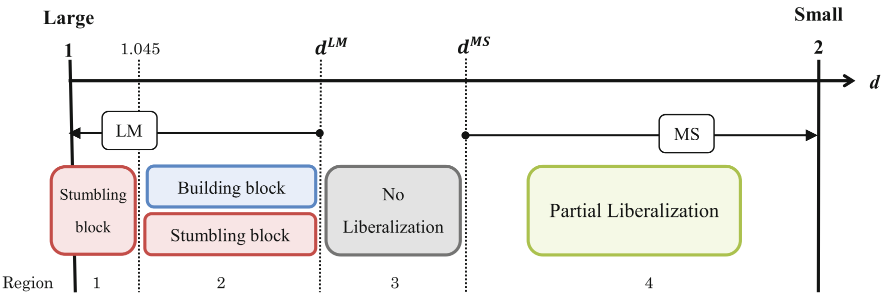

Fig. 2.8 Summary of results

it in the initial situation. The same logic is applied to country *M* for the formation of a spoke-spoke M-S FTA.

Let us consider how the mode of competition affects the feasibility of MFT through formation of a bilateral FTA. Figures 2.6 and 2.7 indicate that Stackelberg competition reduces the attainability of MFT. Suppose that L-M FTA is formed. Under Cournot competition, formation of an L-S FTA as well as an M-S FTA may act as a building block via overlapping FTAs. However, under Stackelberg competition, while an L-M FTA may be a building block, an M-S FTA is never achieved. We should note that Stackelberg competition, as compared with Cournot competition, reduces the feasibility of an L-M FTA. In addition, as shown in Fig. 2.8, there is a possibility of no liberalization under Stackelberg competition, while at least one kind of FTA is formed under Cournot competition. Therefore, this chapter shows that the feasibility of MFT through a bilateral FTA depends on not only differences in market size but also competition mode.

2.5 Concluding Remarks

In this chapter, we examine how the mode of competition affects the feasibility of MFT through formation of a bilateral FTA in the three-country model with asymmetric markets.

The main conclusion we obtain in this chapter is as follows: As compared with Cournot competition, Stackelberg competition lowers the feasibility of a bilateral FTA as well as the attainability of MFT.

In this chapter, we assume that the market sizes of all countries are different. Therefore, it is interesting to confirm the robustness of results under a symmetric market case. It would be interesting to introduce price competition and/or asymmetry among firms into this model.

Acknowledgements This work was supported by JPSS KAKENHI Grant Number 26380318.

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Chapter 3
Sustainability of Free Trade Agreements Under a Maximum Revenue Tariff

Makoto Okamura and Takao Ohkawa

Abstract This chapter examines the sustainability of multilateral free trade (MFT) or a bilateral free trade agreement (FTA) in a welfare-maximizing tariff regime compared with that in a revenue-maximizing tariff regime. To do so, we construct a framework consisting of three countries, each of whose markets are segmented, and three firms, each of which supplies its product in the three markets. We examine the sustainability of the FTAs by using a repeated game setting. We establish the following: (1) MFT is less sustainable in a revenue-maximizing tariff regime than in a welfare-maximizing tariff regime, while a bilateral FTA has almost the same sustainability in both regimes. (2) Suppose that a bilateral FTA is formed. Expansion of the FTA is more sustainable in a revenue-maximizing tariff regime than in a welfare-maximizing tariff regime. An FTA may be a building block (a stumbling block) to MFT in a revenue-maximizing tariff regime (a welfare-maximizing tariff regime).

Keywords FTA • MFT • Sustainability • Welfare-maximizing tariff regime • Revenue-maximizing tariff regime

3.1 Introduction

There is some research about the sustainability of multilateral free trade (MFT) and/or regional trade agreements (RTAs), i.e., FTAs and customs unions (CU), even if they are restricted to a theoretical approach using a repeated game with a homogenous Cournot oligopoly. Fung and Schneider (2005) and Saggi et al. (2007), for instance, dealt with the sustainability of MFT. Fung and Schneider (2005) considered trade integration between North and South countries by examining a

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*, New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_3

two-country segmented market model with differences in both market size and wage rate and showed that an increase in these differences deteriorates the sustainability of trade integration. Saggi et al. (2007) compared the degree of the sustainability of MFT in the most favored nation (MFN) regime with that in the tariff discrimination regime in the asymmetric trio-poly model. They showed that MFN increases the likelihood of MFT sustainability.

Freund (2000) compared the sustainability of an RTA, i.e., FTA and CU, with that of MFT in a repeated game with three symmetric countries with segmented markets and showed that MFT is more likely to be sustainable than an RTA. Nielsen (2006) considered whether an RTA is a stepping stone or a stumbling block to global free trade by comparing the equilibrium in a static RTA/MFT formation game with that in a dynamic one. He constructed the countries' segmented markets with different sizes. He showed that a CU (MFT) is supported at static equilibrium, while MFT (a CU) is supported at dynamic equilibrium under a certain market size difference and concluded that a stepping stone (a stumbling block) to MFT prevails.

While the abovementioned articles examined sustainability under "noncooperative" regimes where no countries form RTAs, Saggi (2006) and Missios and Yildiz (2015) examined the sustainability of MFT in the situation where an RTA is formed. Using three symmetric countries with segmented markets, Saggi (2006) established the following results: Suppose that a bilateral FTA (a bilateral CU) is formed. MFT is less sustainable under an RTA regime than under a "noncooperative" regime because the existing FTA (CU) reduces the range of the nonmember's sustainability (CU members' sustainability). Missios and Yildiz (2015), whose research can be regarded as an extension of Saggi' s (2006), constructed a four-country model consisting of two efficient North countries and two inefficient South countries and considered the three types of RTAs, i.e., North–North FTA, North–South FTA, and South–South FTA. They showed the possibility that only the South–South RTA becomes a stepping stone to MFT in the sense that the range of sustainability of MFT under the South–South RTA regime is wider than that under the "noncooperative" regime in certain conditions.

Although previous researchers present richer results about the sustainability of RTAs and/or MFT, they assume that a country's government sets its tariff rate in order to maximize its welfare when it does not join an RTA or MFT or when it becomes an RTA or MFT member and imposes an external tariff on outsider firms. In other words, a government can be regarded as a benevolent dictator.

However, Brennan and Buchanan (1977) presented an alternative view: the government can be regarded as a Leviathan, i.e., tax revenue maximizer. This view has filtered into the fields of economics. In the field of tax competition, for instance, Edwards and Keen (1996) and Itaya et al. (2014) dealt with the behavior of a Leviathan government. In international economics with oligopoly, Collie (1991) and Clarke and Collie (2006) compared the equilibrium outcome if the tariff-setting government is a welfare maximizer or a revenue maximizer.

This chapter examines the sustainability of an FTA and/or MFT in the situation where the government behaves like a Leviathan government, imposing a tariff on the foreign (outsider) firms, and compares the range of sustainability. Note that each of the Leviathan governments is assumed to behave as welfare maximizer only when it forms MFT or FTA.

We establish the following. (1) MFT is less sustainable in a revenue-maximizing tariff regime than in a welfare-maximizing tariff one, while a bilateral FTA is almost as sustainable in a revenue-maximizing tariff regime as in a welfare-maximizing tariff regime. (2) Suppose that a bilateral FTA is formed. Expansion of the FTA is more sustainable in a revenue-maximizing tariff regime than in a welfare-maximizing tariff regime. An FTA may be a building block (a stumbling block) to MFT in a revenue-maximizing tariff regime (a welfare-maximizing tariff regime).

The rest of this chapter is organized as follows. Section 3.2 presents our analytical model. Section 3.3 shows the preliminary results. In Sect. 3.4 (3.5), we consider the sustainability of MFT (FTA) in the above two tariff regimes. In Sect. 3.6, we examine whether FTA is a building block or a stumbling block for MFT. Section 3.7 concludes.

3.2 Setup

We construct the model used in Freund (2000) and Saggi (2006). There are three countries, country 1, country 2, and country 3. Each country $i(=1,2,3)$ has a symmetric segmented market i, whose demand function is given by

$$p_i = a - Q_i, \tag{3.1}$$

where a is demand parameter and Q_i is total output in the market i.

There are three firms: firm 1, firm 2, and firm 3. Firm h is in country $h(=1,2,3)$. The quantities supplied by firm h in market i are represented by q_{ih}. Note that

$$Q_i = q_{i1} + q_{i2} + q_{i3}. \tag{3.2}$$

The unit cost supplied by firm h in market i is represented by $0 \leq c(< a)$. Each firm h faces a specific tariff rate t_{ih} when it operates in market i. Note also that $t_{ii} = 0$. From (3.1) and (3.2), the firm h's profit in market i denoted by π_{ih} is

$$\pi_{ih} = (p_i - c - t_{ih})q_{ih} = (a - c - t_{ih} - Q_i)q_{ih}. \tag{3.3}$$

Henceforth, we assume that $a - c = 1$ for simplicity.

Each firm h behaves in a Cournot fashion in each market i given the tariff rate t_{ih}. We derive the following function from the first-order condition as

$$q_{ih} = (1 - t_{ih}) - Q_i. \tag{3.4}$$

Using Cournot aggregation in Bergstrom and Varian (1985), from (3.4) we obtain the total output in market i as

$$Q_i = \frac{1}{4}\left(3 - \sum_{h=1}^{3} t_{ih}\right). \tag{3.5}$$

Substituting (3.5) into (3.4) yields

$$q_{ih} = \frac{1}{4}\left(1 - 3t_{ih} + \sum_{l \neq h} t_{il}\right). \tag{3.6}$$

From (3.3) and (3.6), we have

$$\pi_{ih} = (x_{ih})^2 = \frac{1}{16}\left(1 - 3t_{ih} + \sum_{l \neq h} t_{il}\right)^2 \tag{3.7}$$

3.3 Preliminary Results

In this section, we derive the equilibrium outcomes of a Nash tariff-setting game and free trade. In Sect. 3.3.1, we deal with the Nash tariff-setting game, where each government behaves as a welfare maximizer, while we consider the case where it behaves as a tariff revenue maximizer in Sect. 3.3.2. We examine the free trade case in Sect. 3.3.3. We summarize the equilibrium outcomes in these cases in Sect. 3.3.4.

3.3.1 *Welfare-Maximizing Tariff Game*

Each government i sets its tariff rate t_{ih} to maximize its welfare W_i, which is defined as the sum of consumer surplus CS_i, producer surplus PS_i, and tariff revenue TR_i. From (3.5), (3.6), and (3.7), we can express W_i as

$$\begin{aligned} W_i &= CS_i + PS_i + TR_i, \\ &= \frac{1}{2}Q_i^2 + \left(q_{ii}^2 + \sum_{m \neq i} q_{mi}^2\right) + \sum_{h=1}^{3} t_{ih} q_{ih}, \end{aligned} \tag{3.8}$$

where $t_{ii} = 0$. The first-order condition for welfare maximization is

$$\frac{\partial W_i}{\partial t_{ih}} = Q_i \frac{\partial Q_i}{\partial t_{ih}} + 2q_{ii}\frac{\partial q_{ii}}{\partial t_{ih}} + \left(q_{ih} + t_{ih}\frac{\partial q_{ii}}{\partial t_{ih}} + \frac{\partial q_{il}}{\partial t_{ih}}\right) = 0 \tag{3.9}$$

where $(i, h, l) = (1, 2, 3)$ and $i \neq h$, $i \neq l$, and $h \neq l$ from (3.8). After some manipulation, (3.9) can be transformed into

$$3 - 21t_{ih} + 11t_{il} = 0. \tag{3.10}$$

From (3.10), therefore, we obtain the equilibrium tariff rate

$$t_{ih}^{NW} = t_{il}^{NW} = \frac{3}{10}, \tag{3.11}$$

where the superscript *NW* stands for a welfare-maximizing tariff in a Nash tariff-setting game. From (3.6), (3.7), (3.8), and (3.11), we can derive the equilibrium outcomes.

3.3.2 Maximum Revenue Tariff Game

Each government i is supposed to set its tariff rate $t_{ih} (i \neq h)$ to maximize its tariff revenue, TR_i, which is given by

$$TR_i = \sum_{h \neq i} t_{ih} q_{ih}, \tag{3.12}$$

from (3.8). The first-order condition for tariff revenue maximization is

$$q_{ih} + t_{ih} \frac{\partial q_{ii}}{\partial t_{ih}} + \frac{\partial q_{il}}{\partial t_{ih}} = 0,$$

which can be transformed into

$$1 - 6t_{ih} + 2t_{il} = 0. \tag{3.13}$$

where $i \neq h$, $i \neq l$, and $h \neq l$. From (3.13), therefore, we derive the maximum tariff rate

$$t_{ih}^{NM} = t_{il}^{NM} = \frac{1}{4}, \tag{3.14}$$

where the superscript *NM* stands for a revenue-maximizing tariff in a Nash tariff-setting game. From (3.6), (3.7), (3.8), and (3.14), we can derive the equilibrium outcomes.

Table 3.1 Equilibrium outcomes in NW, NM, and FT cases

Cases ╲ outcomes	CS_i^n	π_{ii}^n	π_{im}^n	TR_i^n
Welfare-maximizing tariff (NW)	$\frac{9}{50}$	$\frac{4}{25}$	$\frac{1}{100}$	$\frac{3}{50}$
Revenue-maximizing tariff (NM)	$\frac{25}{128}$	$\frac{9}{64}$	$\frac{1}{64}$	$\frac{1}{16}$
Free trade (FT)	$\frac{9}{32}$	$\frac{1}{16}$	$\frac{1}{16}$	0

3.3.3 Free Trade

In free trade, the tariff vanishes, i.e.

$$t_{ij}^{FT} = 0, \tag{3.15}$$

where the superscript FT stands for free trade. From (3.6), (3.7), (3.8), and (3.15), we can derive the equilibrium outcomes.

3.3.4 Equilibrium Outcomes

We show the equilibrium outcomes in country i under the above three cases in Table 3.1. Note that $i \neq m$ and that $n = NW, NM,$ and FT.

From (3.11), (3.14), and Table 3.1, we derive the following result.

Proposition 3.1

(i) The equilibrium tariff rate under a welfare-maximizing tariff regime is higher than that under a revenue-maximizing tariff regime.
(ii) The equilibrium welfare level under a welfare-maximizing tariff regime is also higher than that under a revenue-maximizing tariff regime.

From Table 3.1, we recognize that the switching tariff regimes from revenue maximizing to welfare-maximizing enhances only the home market's profit π_{ii}, whereas it reduces the other components. Since the increase in the home market's profit dominates the decrease in the other components, the welfare level under a welfare-maximizing tariff regime is higher than that under a revenue-maximizing tariff regime. Proposition 3.1 therefore implies that if the government behaves in a more protective fashion, then it improves its welfare.

3.4 Sustainability for MFT Under No FTA

In this section, we examine the sustainability of MFT among countries i, j, and k in the situation where no governments form a bilateral FTA using a repeated game setting. We assume that each country's government determines the formation of MFT or FTA from a welfare viewpoint. We also assume a common discount factor denoted by $\delta_i \in (0,1)$ for $i = 1, 2, 3$. We solve for equilibrium where all governments play a Nash tariff-setting game using the grim trigger strategy for punishment.

We consider the sustainability of MFT when a welfare-maximizing tariff (a revenue-maximizing tariff) is set in Sect. 3.4.1 (3.4.2). The Sect. 3.4.3 compares two sustainable conditions.

3.4.1 Sustainability of MFT Under a Welfare-Maximizing Tariff

We consider the sustainability of MFT when a welfare-maximizing tariff rate is set in the Nash tariff-setting game. Using a grim trigger strategy, we obtain the sustainable condition of MFT as follows:

$$\frac{1}{1-\delta_i} W_i^{FT} \geq W_i^{DW-FT} + \frac{\delta_i}{1-\delta_i} W_i^{NW}, \tag{3.16}$$

where W_i^{DW-FT} is a country i's welfare when its government deviates from MFT and set its tariff rate to maximize its welfare. Since all markets are segmented and all firms use production technology with constant returns to scale, the tariff rate is equal to t_{im}^{NW} in the deviation stage. Therefore, country i's welfare in the deviation stage is given by

$$W_i^{DW-FT} = CS_i^{NW} + \pi_{ii}^{NW} + \pi_{ji}^{FT} + \pi_{ki}^{FT} + TR_i^{NW}. \tag{3.17}$$

We can obtain a critical value of the sustainability for MFT from (3.16) and (3.17) as

$$\begin{aligned} \delta_i \geq \delta_i^{FT-W} &= \frac{W_i^{DW-FT} - W_i^{FT}}{W_i^{DW-FT} - W_i^{NW}} \\ &= \frac{(CS_i^{NW} - CS_i^{FT}) + (\pi_{ii}^{NW} - \pi_{ii}^{FT}) + TR_i^{NW}}{(\pi_{ji}^{FT} - \pi_{ji}^{NW}) + (\pi_{ki}^{FT} - \pi_{ki}^{NW})}. \end{aligned} \tag{3.18}$$

From Table 3.1 and (3.18), after some calculations, we have

$$\delta_i^{FT-W} = \frac{\frac{9}{160}}{\frac{21}{200}} \frac{15}{28} \approx 0.536. \tag{3.19}$$

3.4.2 Sustainability of MFT Under a Maximum Revenue Tariff

We consider the sustainability of MFT when a maximum revenue tariff rate is set in the Nash tariff-setting game. Sustainable conditions of MFT similar to (3.16) are obtained. In the deviation stage, the tariff rate set by country i's government equals t_{im}^{NM}. Therefore, we have

$$\delta_i \geq \delta_i^{FT-M} = \frac{W_i^{DM-FT} - W_i^{FT}}{W_i^{DM-FT} - W_i^{NM}} = \frac{(CS_i^{NM} - CS_i^{FT}) + (\pi_{ii}^{NM} - \pi_{ii}^{FT}) + TR_i^{NM}}{(\pi_{ji}^{FT} - \pi_{ji}^{NM}) + (\pi_{ki}^{FT} - \pi_{ki}^{NM})}. \tag{3.20}$$

where W_i^{DM-FT} is a country i's welfare when its government deviates from MFT. From Table 3.1 and (3.20), after some calculations, we have

$$\delta_i^{FT-M} = \frac{\frac{7}{128}}{\frac{3}{32}} = \frac{7}{12} \approx 0.582. \tag{3.21}$$

3.4.3 Comparison of Sustainable Conditions

From (3.19) and (3.21), we establish

Proposition 3.2 *Suppose that no governments form bilateral FTAs. The government that adopts a welfare-maximizing tariff in a Nash tariff-setting game is more willing to sustain MFT than the government that adopts a maximum revenue tariff.*

We consider the per stage benefits of deviation from MFT, given by

$$\begin{aligned}(W_i^{DW-FT} - W_i^{FT}) &- (W_i^{DM-FT} - W_i^{FT}) \\ &= (CS_i^{NW} - CS_i^{NM}) + (\pi_{ii}^{NW} - \pi_{ii}^{NM}) + (TR_i^{NW} - TR_i^{NM}) \qquad (3.22) \\ &= \frac{9}{160} - \frac{7}{128} \approx 0.00156 > 0\end{aligned}$$

from Table 3.1. We also consider the per stage costs of deviation from MFT, given by

$$\begin{aligned}(W_i^{DW-FT} - W_i^{NW}) &- (W_i^{DM-FT} - W_i^{NM}) \\ &= (\pi_{ji}^{NW} - \pi_{ji}^{NM}) + (\pi_{ki}^{NW} - \pi_{ki}^{NM}) \qquad (3.23) \\ &= \frac{21}{200} - \frac{3}{32} = 0.01125 > 0\end{aligned}$$

The welfare-maximizing tariff rate is higher than the revenue-maximizing tariff rate from (3.11) and (3.14). This means that the first and the third terms of (3.22) are negative, while the second one is positive. This also means that the first and the second terms of (3.23) are positive. Certainly, both the benefits and the costs associated with deviation are positive, but the benefits are smaller than costs. Therefore, deviation from MFT in the welfare-maximizing tariff case is costlier than in the revenue-maximizing tariff case. That is why MFT in the welfare-maximizing tariff case is more sustainable than in the revenue-maximizing tariff case.

3.5 Sustainability of an FTA Under No FTA

In this section we examine the sustainability of a bilateral FTA. We solve the external tariff rate for firm k when a bilateral FTA between countries i and j and show the equilibrium outcomes in the FTA in the Sect. 3.5.1. In Sects. 3.5.2 and 3.5.3, we explore the sustainability of an FTA between countries i and j with a welfare-maximizing tariff (a revenue-maximizing tariff). We show the results in the Sect. 3.5.4.

3.5.1 External Tariff Rate

Suppose that a bilateral FTA between countries i and j is formed. Then $t_{ij} = t_{ji} = 0$. The adoption by government i of a welfare-maximizing tariff, substituting $t_{ij} = 0$ into (3.10), yields the external tariff rate t_{ik}^{EW} that is imposed on firm k:

$$t_{ik}^{EW} = \frac{1}{7}. \tag{3.24}$$

If government i adopts a revenue-maximizing tariff, substituting $t_{ij} = 0$ into (3.13) yields the external tariff rate t_{ik}^{EM}, which is given by

$$t_{ik}^{EM} = \frac{1}{6}. \tag{3.25}$$

From (3.24) and (3.25), we establish

Proposition 3.3 *The external tariff rate imposed on a nonmember firm in the welfare-maximizing tariff case is smaller than that in the revenue-maximizing tariff case.*

From (3.6), (3.7), (3.8), (3.24), and (3.25), we derive the equilibrium outcomes of FTA member countries. They are shown in Table 3.2 where $n = AW, AM$. Note that the profit level of the member country's firm in the nonmember country k's market is equal to its profit level in the Nash tariff-setting game.

Table 3.2 Equilibrium outcomes of FTA members

Cases ＼ outcomes	CS_i^n	π_{ii}^n	π_{ij}^n	π_{ik}^n	TR_i^n
Welfare-maximizing tariff (AW)	$\frac{25}{98}$	$\frac{4}{49}$	$\frac{4}{49}$	$\frac{1}{100}$	$\frac{1}{49}$
Revenue-maximizing tariff (AM)	$\frac{289}{1152}$	$\frac{49}{576}$	$\frac{49}{576}$	$\frac{1}{100}$	$\frac{1}{48}$

Table 3.3 Equilibrium outcomes of FTA nonmember

Cases ＼ outcomes	CS_k^n	π_{kk}^n	π_{ki}^n	π_{kj}^n	TR_k^n
Welfare-maximizing tariff (AW)	$\frac{9}{50}$	$\frac{4}{25}$	$\frac{1}{49}$	$\frac{1}{49}$	$\frac{3}{50}$
Revenue-maximizing tariff (AM)	$\frac{28}{125}$	$\frac{9}{64}$	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{1}{16}$

When both countries i and j form a bilateral FTA, the outsider country k's equilibrium outcomes are also derived from (3.7), (3.24), (3.25), and Table 3.1, as shown in Table 3.3.

From (3.24) and (3.25), and Tables 3.2 and 3.3, we derive

Proposition 3.4

(i) The equilibrium tariff rate under a welfare-maximizing tariff regime is lower than that under a revenue-maximizing tariff regime.

(ii) The levels of welfare in both member and nonmember countries under a welfare-maximizing tariff regime are lower than under a revenue tariff regime.

According to Tables 3.2 and 3.3, switching from a welfare-maximizing tariff regime to a revenue-maximizing tariff regime enables member countries to enhance tariff revenue as well as their firms' profits in member countries' markets, while it enables them to reduce consumer surplus. These changes are caused by an increase in the external tariff rate, and the reduction in consumer surplus dominates the enhanced tariff revenue and firm profits. Thus, a member country's government improves its welfare by implementing a more protective policy toward a nonmember firm.

For a nonmember country, however, the switch enhances consumer surpluses and tariff revenue and reduces producer surplus, because of the decrease in the tariff rate imposed by the nonmember country's government and the increase in the external tariff rate. The former increase dominates the latter decrease. Thus, a nonmember country's government improves its welfare by implementing a more less protective policy toward a member firm.

3.5.2 Sustainability of an FTA Under a Welfare-Maximizing Tariff Regime

The sustainable condition is given by

$$\frac{1}{1-\delta_i} W_i^{AW} \geq W_i^{DW-A} + \frac{\delta_i}{1-\delta_i} W_i^{NW}, \tag{3.26}$$

where W_i^{DW-A} is country i's welfare when its government deviates from the FTA and sets its tariff rate to maximize its welfare. As mentioned above, the tariff rate is equal to t_{im}^{NW} for $m = j, k$ in the deviation stage. Therefore, member country i's welfare in the deviation stage is given by

$$W_i^{DW-A} = CS_i^{NW} + \pi_{ii}^{NW} + \pi_{ji}^{AM} + \pi_{ki}^{NW} + TR_i^{NW}. \tag{3.27}$$

From (3.26) and (3.27), we obtain

$$\begin{aligned}\delta_i \geq \delta_i^{A-W} &= \frac{W_i^{DW-A} - W_i^{AW}}{W_i^{DW-A} - W_i^{NW}} \\ &= \frac{(CS_i^{NW} - CS_i^{AW}) + (\pi_{ii}^{NW} - \pi_{ii}^{AW}) + (TR_i^{NW} - TR_i^{AW})}{\pi_{ji}^{AW} - \pi_{ji}^{NW}}.\end{aligned} \tag{3.28}$$

We can obtain a critical value of the sustainability of an FTA from Tables 3.1 and 3.2 as

$$\delta_i^{A-W} = \frac{\frac{3}{70}}{\frac{351}{4900}} = \frac{70}{117} \approx 0.598. \tag{3.29}$$

From (3.19) and (3.29), we establish

Proposition 3.5 (Freund 2000) *Suppose that all governments adopt a welfare-maximizing tariff. MFT is more sustainable than FTA between countries i and j.*

We compare the per stage cost of deviation from MFT within an FTA. Certainly both the benefit and cost of the deviation from MFT are higher than those of the deviation from FTA, i.e., $\frac{9}{160} \approx 0.0563 > 0.043 \approx \frac{3}{70}$ and $\frac{21}{200} \approx 0.105 > 0.072 \approx \frac{351}{4900}$, due to the existence of outsider country k that plays a Nash tariff-setting game. However, the benefit is smaller than that the cost. This implies that the punishment of deviation from MFT is more severe than that from an FTA. That is why MFT is more sustainable than an FTA.

3.5.3 Sustainability of an FTA Under a Maximum Revenue Tariff Regime

In the deviation stage, the welfare level of country i is given by

$$W_i^{DM-A} = CS_i^{NM} + \pi_{ii}^{NM} + \pi_{ji}^{AM} + \pi_{ki}^{NM} + TR_i^{NM}. \tag{3.30}$$

From (3.30), we derive the sustainable condition as follows:

$$\delta_i \geq \delta_i^{A-M} = \frac{W_i^{DM-A} - W_i^{AM}}{W_i^{DM-A} - W_i^{NW}}$$
$$= \frac{(CS_i^{NM} - CS_i^{AM}) + (\pi_{ii}^{NM} - \pi_{ii}^{AM}) + (TR_i^{NM} - TR_i^{AM})}{\pi_{ji}^{AM} - \pi_{ji}^{NM}}. \quad (3.31)$$

Tables 3.1 and 3.2 enable us to calculate the explicit number of the critical value δ_i^{A-M} as

$$\delta_i^{A-M} = \frac{\frac{1}{24}}{\frac{5}{72}} = \frac{3}{5} = 0.6. \quad (3.32)$$

From (3.21) and (3.32), we establish

Proposition 3.6 *Suppose that all governments adopt a revenue-maximizing tariff. MFT is more sustainable than an FTA between countries i and j.*

3.5.4 Comparison Between Two Tariff Schemes

We make a comparison of the sustainability of an FTA under a welfare-maximizing tariff scheme and a revenue-maximizing tariff scheme. From (3.29) and (3.32), we establish

Proposition 3.7 *An FTA with a welfare-maximizing tariff is almost as sustainable as an FTA with a revenue-maximizing tariff.*

Subtracting the benefit of the deviation with the maximum revenue tariff from that with the welfare-maximizing tariff yields approximately 0.001, while subtracting the cost of the deviation with the maximum revenue tariff from that with the welfare-maximizing tariff yields approximately 0.003. This mean that the punishment of deviation from an FTA with the welfare-maximizing tariff is more severe than that with the maximum revenue tariff, because the difference between the Nash tariff rate and the external tariff one with the welfare-maximizing tariff is higher than the difference between the tariffs with the maximum revenue tariff from Proposition 3.3.

3.6 Sustainability of MFT Under a Bilateral FTA

This section examines the sustainability of MFT under both welfare-maximizing tariff and maximum revenue tariff regimes, given a bilateral FTA. Hereafter, we can focus on whether outsider country 1 joins an FTA between countries 2 and 3 under the assumption of symmetric countries and firms. Following Saggi (2006) and Missios and Yildiz (2015), we assume that a given FTA is not terminated. In Sect. 3.6.1, we solve the critical value of the discount factor on MFT under a welfare-maximizing tariff; we solve it under a revenue-maximizing tariff in Sect. 3.6.2. We consider whether an FTA becomes a building block or a stumbling block to free trade in Sect. 3.6.3.

3.6.1 Sustainability Under a Welfare-Maximizing Tariff Regime

First, we consider the sustainable condition under which an outsider country 1 becomes a member of MFT. The condition is expressed as

$$\frac{1}{1-\delta_1} W_1^{FT} \geq W_1^{DW-FT-23} + \frac{\delta_1}{1-\delta_1} W_1^{NW-23}, \tag{3.33}$$

where $W_1^{DW-FT-23}$ is country 1's welfare level such that country 1's government deviates from MFT, and W_1^{NW-23} is the level of country 1's welfare such that country 1 is regarded as an outsider under the FTA between countries 2 and 3. These welfare levels are given by

$$W_1^{DW-FT-23} = CS_1^{NW} + \pi_{11}^{NW} + \pi_{21}^{FT} + \pi_{31}^{FT} + TR_1^{NW}, \tag{3.34}$$

$$W_1^{NW-23} = CS_1^{NW} + \pi_{11}^{NW} + \pi_{21}^{AW} + \pi_{31}^{AW} + TR_1^{NW}. \tag{3.35}$$

From (3.33) through (3.35) and Tables 3.1 and 3.3, we solve the critical value of sustainability of MFT for a nonmember country as follows:

$$\begin{aligned}
\delta_1 \geq \delta_1^{FT-W-23} &= \frac{W_1^{DW-FT-23} - W_1^{FT}}{W_1^{DW-FT-23} - W_1^{NW-23}} \\
&= \frac{(CS_1^{NW} - CS_1^{FT}) + (\pi_{11}^{NW} - \pi_{11}^{FT}) + TR_1^{NW}}{(\pi_{21}^{FT} - \pi_{21}^{AW}) + (\pi_{31}^{FT} - \pi_{31}^{AW})} \\
&= \frac{\frac{9}{160}}{\frac{33}{392}} \approx \frac{0.05625}{0.08418} \\
&= \frac{147}{220} \approx 0.6682.
\end{aligned} \tag{3.36}$$

Next, we consider the sustainability of MFT for member country $i (= 2, 3)$. The sustainability condition is expressed as

$$\frac{1}{1-\delta_i} W_i^{FT} \geq W_i^{DW-FT-23} + \frac{\delta_1}{1-\delta_i} W_i^{AW}, \tag{3.37}$$

where $W_i^{DW-FT-23}$ is member country i's welfare level when it deviates from MFT and does not deviate from the FTA. From (3.37) and Tables 3.1 and 3.2, we derive the critical value of δ_i:

$$\begin{aligned}\delta_i \geq \delta_i^{FT-W-23} &= \frac{W_i^{DW-FT-23} - W_i^{FT}}{W_i^{DW-FT-23} - W_i^{AW}} \\ &= \frac{(CS_i^{AW} - CS_i^{FT}) + (\pi_{ii}^{AW} - \pi_{ii}^{FT}) + TR_i^{AW}}{(\pi_{1i}^{FT} - \pi_{1i}^{AW}) + (\pi_{ji}^{FT} - \pi_{ji}^{AW})} \\ &= \frac{\frac{21}{1568}}{\frac{327}{9800}} \approx \frac{0.01339}{0.03337} \\ &= \frac{8575}{21364} \approx 0.401 \qquad (3.38)\end{aligned}$$

for $(i, j) = (2, 3)$ and $i \neq j$. From (3.36) and (3.38), we establish

Proposition 3.8 *Suppose that a bilateral FTA is formed. If the discount factor of all countries is not less than the critical value* $\frac{147}{220}$*, then the MFT is sustainable.*

When nonmember country 1 deviates from MFT, firm 1 is protected by the Nash tariff in market 1 and faces free trade in markets 2 and 3; however, when member country 2, for instance, deviates from MFT, the external tariff is imposed on firm 1 in market 2, and no tariffs exist in markets 1 and 3. The benefit of the deviation for nonmember country 1 is therefore much larger than that for member country 2.

The cost of the deviation for nonmember country 1 is the reduction of firm 1's profit by imposition of the external tariff in markets 2 and 3; however, the cost for member country 2 is the net reduction of firm 2's profit consisting of the profit reduction imposed by the Nash tariff in market 1 and the profit increase caused by imposition of the external tariff on firm 1 in market 3. Therefore, the cost of deviation for nonmember country 1 is relatively larger than that for member country 2. Thus, the incentive to deviate from MFT for a nonmember is larger than that for a member country. Note that the proposition 3.6 can also be explained by the same logic as that in Proposition 3.8.

3.6.2 Sustainability Under a Revenue-Maximizing Tariff Regime

We derive the sustainable condition of MFT such that nonmember country 1 joins the bilateral FTA between countries 2 and 3, which is given by

$$\delta_1 \geq \delta_1^{FT-M-23} = \frac{W_1^{DM-FT-23} - W_1^{FT}}{W_1^{DM-FT-23} - W_1^{NM-23}}, \qquad (3.39)$$

where $W_1^{DM-FT-23}$ (W_1^{NM-23}) denotes the welfare level of country 1 in the deviation stage (in the punishment stage). These welfare levels are defined as

$$W_1^{DM-FT-23} = CS_1^{NM} + \pi_{11}^{NM} + \pi_{21}^{FT} + \pi_{31}^{FT} + TR_1^{NM}, \tag{3.40}$$

$$W_1^{NM-23} = CS_1^{NM} + \pi_{11}^{NM} + \pi_{21}^{AM} + \pi_{31}^{AM} + TR_1^{NM}. \tag{3.41}$$

From (3.39) through (3.41) and Tables 3.1 and 3.3, we derive the critical value of sustainability of MFT for a nonmember country as

$$\begin{aligned}\delta_1^{FT-M-23} &= \frac{(CS_1^{NM} - CS_1^{FT}) + (\pi_{11}^{NM} - \pi_{11}^{FT}) + TR_1^{NM}}{(\pi_{21}^{FT} - \pi_{21}^{AM}) + (\pi_{31}^{FT} - \pi_{31}^{AM})} \\ &= \frac{\frac{7}{128}}{\frac{3}{32}} \approx \frac{0.05469}{0.09375} \\ &= \frac{7}{12} \approx 0.583. \end{aligned} \tag{3.42}$$

$W_i^{DM-FT-23}$ (W_i^{NM-23}) denotes the welfare level of FTA member country $i(= 2, 3)$ in the deviation stage (in the punishment stage). The sustainable condition for member country $i(= 2, 3)$ is expressed as

$$\begin{aligned}\delta_i \geq \delta_i^{FT-M-23} &= \frac{W_i^{DM-FT-23} - W_i^{FT}}{W_i^{DM-FT-23} - W_i^{AM}} \\ &= \frac{(CS_i^{AM} - CS_i^{FT}) + (\pi_{ii}^{AM} - \pi_{ii}^{FT}) + TR_i^{AM}}{(\pi_{1i}^{FT} - \pi_{1i}^{AM}) + (\pi_{ji}^{FT} - \pi_{ji}^{AM})}\end{aligned} \tag{3.43}$$

for $(i,j) = (2,3)$ and $i \neq j$. From (3.43) and Tables 3.1 and 3.2, we calculate the critical value, $\delta_i^{FT-M-23}$:

$$\begin{aligned}\delta_i^{FT-M-23} &= \frac{\frac{15}{1152}}{\frac{38}{192}} \approx \frac{0.01302}{0.0243} \\ &= \frac{15}{28} \approx 0.536. \end{aligned} \tag{3.44}$$

Using the same logic as in the welfare-maximizing tariff case, the benefit of deviation for a nonmember is much larger than that for members, while the cost of deviation for a nonmember is relatively larger than that for members. This means that the nonmember's incentive to deviate from MFT is greater than the member's. Thus we establish

Proposition 3.9 *Suppose that a bilateral FTA is formed. If the discount factor of all countries is not less than the critical value* $\frac{7}{12}$*, then the MFT is sustainable.*

3.6.3 Does FTA Become a Building Block or a Stumbling Block to MFT?

First we consider which tariff regime makes MFT more sustainable under a given FTA. Comparing (3.36) with (3.39), we obtain the following result.

Proposition 3.10 *Suppose that a bilateral FTA is formed. Under the FTA, MFT in the revenue-maximizing tariff regime is more sustainable than in the welfare-maximizing tariff regime.*

The intuition behind Proposition 3.10 is as follows. The comparison of (3.11) with (3.14) indicates that the welfare-maximizing government sets its tariff rate larger than the revenue-maximizing government in a tariff-setting game, as pointed out in Proposition 3.1. This implies that the benefit of deviation from MFT for a nonmember in the welfare-maximizing regime is larger than that in the revenue-maximizing regime. That is,

$$W_1^{DW-FT-23} - W_1^{FT} \approx 0.05625 > 0.05469 \approx W_1^{DM-FT-23} - W_1^{FT}.$$

Comparing the external tariff rate between in the two tariff regimes from (3.24) and (3.25), however, we obtain that the external tariff rate in the welfare-maximizing tariff regime is smaller than that in the revenue-maximizing tariff regime as shown in Proposition 3.3. This implies that the punishment in the welfare-maximizing regime is less severe than that in the revenue-maximizing regime. That is,

$$W_1^{DW-FT-23} - W_1^{NW-23} \approx 0.08418 > 0.09375 \approx W_1^{DM-FT-23} - W_1^{NW-23}.$$

Therefore, the welfare-maximizing government faces a higher critical value of the discount factor ensuring MFT sustainability than the revenue-maximizing government.

Next we consider whether a bilateral FTA is a building block or a stumbling block to MFT. From (3.19) and (3.36), as shown in Saggi (2006, Lemma 5), the bilateral FTA enhances the critical value of the discount factor, ensuring sustainability of MFT in the welfare-maximizing tariff regime. In the revenue-maximizing tariff regime, however, the bilateral FTA does not alter the critical value by comparing (3.21) and (3.39). Thus we establish

Proposition 3.11 *Suppose that a bilateral FTA is formed. A bilateral FTA may become a stumbling block toward free trade in the welfare-maximizing tariff regime, but it becomes a stepping stone in the revenue-maximizing regime.*

Proposition 3.11 states that if each country's government is a benevolent government (a Leviathan government) when it sets its tariff rate, then an FTA deteriorates (facilitates) global free trade. Proposition 3.11 also suggests that whether a bilateral FTA is a stepping stone or a stumbling block depends on the regime of tariff setting.

3.7 Concluding Remarks

In this chapter, we examine the sustainability of MFT or a bilateral FTA under the following two regimes: welfare-maximizing tariff regime and revenue-maximizing tariff regime. To do so, we construct the framework consisting of three countries, each of whose market is segmented, and three firms, each of which supplies its product in the three markets. We examine the sustainability of the FTAs by using a repeated game setting. We establish the following: (1) MFT is less sustainable in a revenue-maximizing tariff regime than in a welfare-maximizing tariff regime, while a bilateral FTA is almost as sustainable in a revenue-maximizing tariff regime as in a welfare-maximizing tariff regime. (2) Suppose that a bilateral FTA is formed. Expansion of the FTA is more sustainable in a revenue-maximizing tariff regime than in a welfare-maximizing tariff regime. An FTA may be a stepping stone (a stumbling block) to MFT in a revenue-maximizing tariff regime (a welfare-maximizing tariff regime).

Our analysis focuses only on FTAs. Our model focuses on the three symmetric countries with segmented markets where three symmetric firms operate. Directions for further research include the following. First, we deal with the sustainability of customs unions. Second, we extend our model to N symmetric countries with segmented markets and N symmetric firms. Third, we introduce asymmetric factors, for instance, market size differences and cost differences, into our model.

Acknowledgements This work was supported by Grants-in-Aid for Scientific Research (no. 23530303, 26380340, and 15K03492). All remaining errors are ours.

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Chapter 4
Technology Choice, Firm Behavior, and Free Trade Agreements

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Abstract This chapter examines how the formation of a free trade agreement (FTA) affects firms' technology choices as well as the importing country's welfare in a three-country model. The main conclusions are as follows: (i) The formation of an FTA strengthens the incentive for the member country firm to invest and weakens that of the nonmember country firm. (ii) The FTA may encourage or discourage adoption of new technology by exporting firms. (iii) Only when the formation of an FTA encourages adoption of new technology may the FTA increase the importing country's welfare; generally, it tends to decrease welfare.

Keywords FTA • Cost-reducing R&D • Technology choice

4.1 Introduction

This chapter examines exporting firms' R&D activities in a three-country model, where two exporting countries and one importing country exist. We analyze how a free trade agreement (FTA) between an importing country and one of two exporting countries affects firms' R&D activities and the importing country's welfare. We define the FTA as an elimination of import tariffs against a member exporting country.

In a three-country framework, to our knowledge, few attempts have so far been made to describe the relationship between firms' R&D activities and import tariff policy. Choi (1995), in his pioneering work, considered the effects of optimal tariffs on the technology choice of exporters under the discriminatory tariffs regime and the most favored nation (MFN) clause in the following three-stage game: In the first stage, all firms in the exporting countries invest in cost-reducing R&D activities. In

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*,
New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_4

the second stage, the government of the importing country imposes an import tariff. In the third stage, all firms export their products to the importing country market and compete in Cournot fashion, given the cost level and tariff in place. Choi (1995) showed that a lower marginal cost technology is chosen under the MFN clause, and the importing country's long-run welfare increases with adoption of the MFN clause, while in most cases the exporting countries' welfare decreases.

Based on Choi (1995), Hwang et al. (1997) investigated two cases: (i) a short-run case where firms' cost conditions are given and constant and (ii) a long-run case where firms can invest in cost-reducing R&D activities. They showed that the importing country's welfare is higher under the discriminatory tariffs than under the uniform tariffs in the short run, while it is lower under the discriminatory tariffs than under the uniform tariffs in the long run. Liao (2008) introduced a spillover effect of R&D into Choi (1995)'s model and showed that results in Choi (1995) hold unless the spillover effect is large.

These previous studies have common features as follows: (i) a firm's marginal increase in R&D expenditures *always* reduces its marginal cost and (ii) both firms necessarily undertake innovative activities in the equilibrium.

In reality, however, the marginal increase does not always reduce the marginal cost, and all firms do not necessarily undertake innovative activities. Mills and Smith (1996) considered technology choice in duopoly by assuming a simple case: only when a firm pays a certain amount of R&D expenditure can it reduce its marginal cost. They showed that, if the level of R&D investment is medium, then only one firm undertakes innovative activity. Based on Mills and Smith (1996), therefore, we address an all-inclusive situation including unilateral and bilateral innovative activities in the equilibrium.

In addition, it seems to be difficult to impose the discriminatory tariff among WTO member countries. We consider the formation of FTA between the importing country and one of two exporting countries, which can be implemented under the WTO system. We can regard it as a measure of discriminatory tariff policy.

Main conclusions are as follows: (i) The formation of an FTA strengthens the incentive for the member country firm to invest, while it weakens the incentive for the nonmember country firm. (ii) The FTA may encourage or discourage adoption of the new technology by exporting firms. (iii) When the formation of FTA encourages (discourages) adoption of the new technology, it may increase (decrease) the importing country's welfare.

The rest of the chapter is organized as follows: Sect. 4.2 describes the model. Section 4.3 presents the preliminary results. Section 4.4 shows the main results. Section 4.5 investigates how the FTA affects the importing country's welfare. The final Sect. 4.6 offers conclusions.

4.2 Model

Consider an economy with two exporting countries (denoted by country 1 and country 2) and one importing country (denoted by country 3). Each exporting country has a single firm that produces a homogeneous good and exports it to an importing country market. The linear inverse demand function of the market is given by

$$P = a - Q \tag{4.1}$$

where P is a market price of the product, a represents market scale, and Q is total output. For simplicity, we assume $a = 1$.

Each firm can reduce its marginal cost to zero by the cost-reducing R&D investment before production. A cost function of firm $i (= 1, 2)$ is described as follows:

$$C_i = \begin{cases} F, & \text{if it undertakes R\&D activity} \\ cq_i, & \text{otherwise} \end{cases} \tag{4.2}$$

where c (F) is a marginal cost (R&D expenditure) of firm i. We assume $\frac{2}{5} > c \geq 0$ to ensure a nonnegative condition for output under all patterns of technology chosen by firms.

The government of an importing country may impose an import tariff t_i per product exported by firm i. We examine a *uniform tariff*, that is, $t_i = t$, except for under the FTA regime. The government sets its tariff rate t to maximize its welfare.

Consider the following three-stage game. In the first stage, both firms simultaneously determine whether to undertake the cost-reducing R&D investment. In the second stage, the government of the importing country decides the level of import tariff to maximize its national welfare. In the third stage, given the technology chosen and the level of import tariff, both firms engage in Cournot competition in the importing country market.

From Eqs. (4.1) and (4.2), the profit of firm i is given by

$$\pi_i = Pq_i - tq_i - C_i. \tag{4.3}$$

We solve the subgame-perfect Nash equilibrium of the above game by backward induction.

4.3 Preliminary Analysis

4.3.1 Third-Stage Equilibrium

In the third stage, given the marginal cost and tariff level, each firm competes in Cournot fashion so as to maximize its profit in the importing country market. From Eqs. (4.1),(4.2), and (4.3), each firm's output in the equilibrium is given by

$$q_i = \frac{1}{3}(1 - 2c_i + c_j - 2t_i + t_j),\ (i, j) = (1, 2),\ i \neq j. \tag{4.4}$$

where c_i is as follows:

$$c_i = \begin{cases} 0, & \text{if it undertake R\&D activity} \\ c. & \text{otherwise} \end{cases} \tag{4.5}$$

4.3.2 Equilibrium Tariff Rate Under Uniform Tariff Policy

We suppose that the government of the importing country imposes a uniform tariff on both exporting countries' firms so as to maximize its welfare defined as

$$W_3 = \frac{1}{2}Q^2 + t_1 q_1 + t_2 q_2, \tag{4.6}$$

where the first term on the right-hand side (RHS) represents consumer surplus and the second (third) term of RHS represents tariff revenues from country 1 (country 2). From Eqs. (4.4) and (4.6), the optimal tariff level under the uniform tariff policy, i.e., $t = t_1 = t_2$, is calculated as

$$t^{UT} = \frac{1}{8}(2 - c_i - c_j). \tag{4.7}$$

Note that the superscript UT represents the uniform tariff policy. Substituting Eq. (4.7) into Eq. (4.4), the equilibrium output level of each firm under the uniform tariff policy is derived as

$$q_i^{UT} = \frac{1}{8}(2 - 5c_i + 3c_j). \tag{4.8}$$

From Eqs. (4.1), (4.4), and (4.8), we can obtain the equilibrium outcomes under the uniform tariff policy. They are shown in Table 4.1.

Table 4.1 Equilibrium output under the uniform tariff policy

Firm 1 ╲ Firm 2	Old technology	New technology
Old technology	$\frac{1}{4}(1-c),\ \frac{1}{4}(1-c)$	$\frac{1}{4}\left(1-\frac{5}{2}c\right),\ \frac{1}{4}\left(1+\frac{3}{2}c\right)$
New technology	$\frac{1}{4}\left(1+\frac{3}{2}c\right),\ \frac{1}{4}\left(1-\frac{5}{2}c\right)$	$\frac{1}{4},\ \frac{1}{4}$

Table 4.2 Equilibrium output under the FTA between countries 1 and 3

Firm 1 ╲ Firm 2	Old technology	New technology
Old technology	$\frac{4}{11}(1-c),\ \frac{3}{11}(1-c)$	$\frac{4}{11}\left(1-\frac{3}{2}c\right),\ \frac{3}{11}\left(1+\frac{1}{3}c\right)$
New technology	$\frac{4}{11}\left(1+\frac{1}{2}c\right),\ \frac{3}{11}\left(1-\frac{4}{3}c\right)$	$\frac{4}{11},\ \frac{3}{11}$

4.3.3 Equilibrium Tariff Rate Under FTA

Suppose that countries 1 and 3 form an FTA. The government of the importing country eliminates the import tariff on firm 1, that is, $t_1 = 0$, while it imposes the import tariff on firm 2. Therefore, from Eqs. (4.4) and (4.6), the optimal tariff level on firm 2 under the FTA with country 1 is given by

$$t_2^{FTA} = \frac{1}{11}(1 + 4c_1 - 5c_2). \tag{4.9}$$

Note that the superscript *FTA* represents the FTA with country 1. Substituting Eq. (4.9) into Eq. (4.4), equilibrium output level of each firm under the FTA is derived as follows:

$$q_1^{FTA} = \frac{2}{11}(2 - 3c_1 + c_2),\ q_2^{FTA} = \frac{1}{11}(3 + c_1 - 4c_2). \tag{4.10}$$

From Eqs. (4.1), (4.4), and (4.10), we can obtain the equilibrium outcomes under the FTA between countries 1 and 3 as shown in Table 4.2.

4.4 Technology Choice

As mentioned above, each firm can reduce its marginal cost by investing in cost-reducing R&D expenditure in the first stage. We refer to a technology available for both firms without any R&D cost as *old technology*. The old technology exhibits positive constant marginal cost c. We refer to a technology available for both firms with R&D cost F as *new technology*. The new technology exhibits zero constant marginal cost.

Table 4.3 First-stage subgame under the uniform tariff policy

Firm 1 \ Firm 2	Old technology	New technology
Old technology	$\frac{1}{16}(1-c)^2,\ \frac{1}{16}(1-c)^2$	$\frac{1}{16}\left(1-\frac{5}{2}c\right)^2,\ \frac{1}{16}\left(1+\frac{3}{2}c\right)^2-F$
New technology	$\frac{1}{16}\left(1+\frac{3}{2}c\right)^2-F,\ \frac{1}{16}\left(1-\frac{5}{2}c\right)^2$	$\frac{1}{16}-F,\ \frac{1}{16}-F$

Table 4.4 First-stage subgame under the FTA between countries 1 and 3

Firm 1 \ Firm 2	Old technology	New technology
Old technology	$\frac{16}{121}(1-c)^2,\ \frac{9}{121}(1-c)^2$	$\frac{16}{121}\left(1-\frac{3}{2}c\right)^2,\ \frac{9}{121}\left(1+\frac{1}{3}c\right)^2-F$
New technology	$\frac{16}{121}\left(1+\frac{1}{2}c\right)^2-F,\ \frac{9}{121}\left(1-\frac{4}{3}c\right)^2$	$\frac{16}{121}-F,\ \frac{9}{121}-F$

4.4.1 Uniform Tariff Case

Let us consider the technology choice (R&D investment) of the firms under the uniform tariff policy. The payoff matrix in the first-stage subgame is shown in Table 4.3, which is derived from Table 4.1 and Eq. (4.3). Thus, we have the following proposition about technology choice under the uniform tariff policy:

Proposition 4.1 *Suppose that the government of the importing country imposes the uniform tariff.*

(i) If $F > \frac{5}{64}c(4+c) \equiv F_1^{UT}$*, then both firms choose the old technology.*
(ii) If $F < \frac{5}{64}c(4-5c) \equiv F_2^{UT}$*, then both firms choose the new technology.*
(iii) If $F_1^{UT} > F > F_2^{UT}$*, then the firms choose different technologies.*

Mills and Smith (1996) analyzed technology choice in a domestic duopoly model. Although import tariff weakens the incentive for firms to invest in the cost-reducing R&D, the equilibrium nature is similar to that in Mills and Smith (1996) because of the uniform tariff policy.

4.4.2 FTA Case

Next, we consider the technology choice under the FTA between countries 1 and 3. Because the import tariff on firm 1 is eliminated under the FTA, the firms face different incentives for R&D investment. From Table 4.2 and (4.3), we obtain the payoff matrix, shown in Table 4.4, expressing the first-stage subgame.

Therefore, we have the following results from Table 4.4:

Lemma 4.1 *Suppose that countries 1 and 3 form an FTA.*

(i) If $F > \frac{12}{121}c(4-c) \equiv F_1^{FTA}$*, then adoption of the old technology is the dominant strategy for firm 1.*
(ii) If $F < \frac{12}{121}c(4-3c) \equiv F_2^{FTA}$*, then adoption of the new technology is the dominant strategy for firm 1.*

(iii) If $F_1^{FTA} > F > F_2^{FTA}$, then adoption of technology different from firm 2 is the best response for firm 1.

Lemma 4.2 *Suppose that countries 1 and 3 form an FTA.*

(i) If $F > \frac{8}{121}c(3-c) \equiv F_3^{FTA}$, then adoption of the old technology is the dominant strategy for firm 2.
(ii) If $F < \frac{8}{121}c(3-2c) \equiv F_4^{FTA}$, then adoption of the new technology is the dominant strategy for firm 2.
(iii) If $F_3^{FTA} > F > F_4^{FTA}$, then adoption of technology different from firm 1 is the best response for firm 2.

From Lemmas 4.1 and 4.2, thus, we establish the following results about technology choice under the FTA:

Proposition 4.2 *Suppose that countries 1 and 3 form the FTA.*

(i) If $F > F_1^{FTA}$, then both firms choose the old technology.
(ii) If $F < F_4^{FTA}$, then both firms choose the new technology.
(iii) If $F_1^{FTA} > F > F_4^{FTA}$, then the member country firm 1 uses the new technology, while the nonmember country firm 2 uses the old technology.

Intuition behind Proposition 4.2 is as follows: The FTA eliminates the import tariff on member country firm 1 and lowers firm 1's effective marginal cost as a result. The formation of the FTA increases firm 1's output but decreases firm 2's output. The benefit from R&D investment becomes larger as the firm produces more output. Therefore, the formation of FTA strengthens the incentive for firm 1 to invest in R&D activities, which is shown by $F_1^{FTA} > F_1^{UT}$ and $F_2^{FTA} > F_2^{UT}$. However, the incentive for firm 2 to invest is weakened. In addition, as shown by Eq. (4.9), if the nonmember country firm 2 reduces its marginal cost by R&D investment, then it induces an increase in the external tariff level on the firm. The formation of the FTA lowers firm 2's incentive to invest through these two effects: raising the effective marginal cost and increasing tariff level by the R&D activity, which is shown by $F_3^{FTA} < F_1^{UT}$ and $F_4^{FTA} < F_2^{UT}$. In consequence, the nonmember country firm 2 chooses the old technology when the member country firm 1 uses the new technology under the FTA.

4.4.3 *Effects of FTA on Technology Choice*

We examine how the formation of the FTA affects the firms' R&D activities. From Propositions 4.1 and 4.2, we obtain

Proposition 4.3

(i) If $F_1^{FTA} > F > F_1^{UT}$, then the formation of an FTA encourages R&D activities.
(ii) If $F_2^{UT} > F > F_4^{FTA}$, then it discourages R&D activities.

Let us consider the logic behind Proposition 4.3. As shown above, the formation of an FTA gives a stronger incentive for the member country firm 1 to undertake R&D activities and a weaker incentive for the nonmember country firm 2. Suppose that F is slightly above F_1^{UT}, given c. Then, both firms choose the old technology. In this situation, the formation of an FTA induces adoption of the new technology by the member country firm 1 through the elimination of the import tariff. It encourages firm's R&D activities. Note that the FTA never encourage adoption of the new technology when F is much greater than F_1^{FTA} even though the FTA strengthens firm 1's incentive to invest.

Suppose that F is slightly below F_2^{UT} given c. Both firms use the new technology. In this situation, the FTA discourages the nonmember country firm 2 from adopting the new technology through raising the effective marginal cost and increasing the tariff level by the R&D activity. However, note that if F is much lower than F_4^{FTA}, then the FTA does not change the technology choice.

Suppose that $F_1^{UT} > F > F_2^{UT}$. Under a uniform tariff policy, each firm chooses different technologies, but it is indeterminate which firm chooses the new technology. However, when the FTA is formed, the member country firm 1 is certain to use the new technology, while the nonmember country firm 2 uses the old technology. The formation of an FTA may counter a firm's technology choice, but it never encourages or discourages R&D activities; i.e., only a single firm chooses the new technology. Figure 4.1 summarizes these results. Note that $OO \rightarrow NO$, for instance, indicates that the formation of the FTA between countries 1 and 3 switches from the situation where both firms use the old technology to the situation where the member country 1's firm uses the new technology and the nonmember country 2's firm uses the old one.

Comparing with the results in Hwang et al. (1997), we consider the implication of Proposition 4.3. They examined the long-run situation where firms engage in

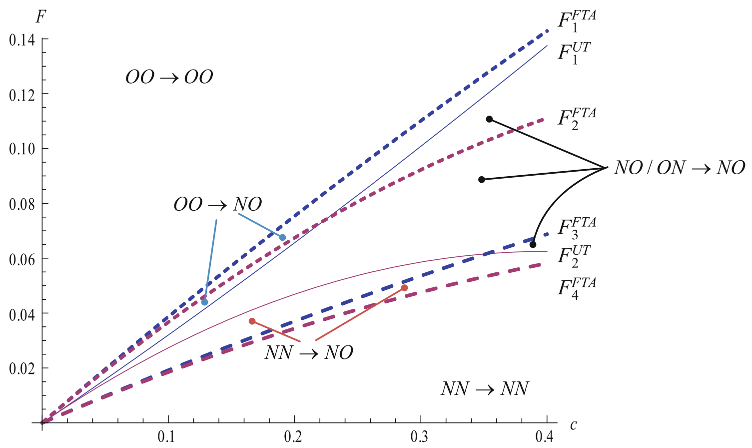

Fig. 4.1 Comparison of technology choice

the cost-reducing R&D investment. They showed that the firms use restraint in investing in R&D under a discriminatory tariff as compared with under a uniform tariff, which induces adoption of technology with a higher marginal cost. This is because lower marginal cost resulting from the R&D increases the level of the tariff on the investing firm. Therefore, firms use restraint in investing in the cost-reducing R&D under a discriminatory tariff in order to lower the tariff. Proposition 4.3 (ii) shows that the formation of an FTA discourages the nonmember country firm 2's R&D activity, and firm 2 adopts the old technology with a higher marginal cost. This result corresponds to that in Hwang et al. (1997). However, Proposition 4.3 (i) shows that the FTA may encourage the member country firm 1's R&D activity. This result contrasts with that in Hwang et al. (1997) and begs the question of why such a difference arises.

Hwang et al. (1997) compared the uniform tariff case with the discriminatory tariff case. Meanwhile, we assume the FTA, not the discriminatory tariff policy. As shown in Eqs. (4.7) and (4.9), the reduction of marginal cost by the R&D investment raises the tariff level on the investing firm under both the uniform tariff and the FTA, which discourages engagement in R&D activity. Consider under which policy the disincentive effect becomes stronger. Under the FTA, the proportion of tariff revenue in the importing country's welfare becomes smaller and that of consumer surplus becomes larger. When the FTA is formed, firm 1 has lower marginal cost than firm 2 because only nonmember country firm 2 faces the tariff. From the viewpoint of importing country welfare, it is desirable for the efficient firm 1 to produce much more because the expansion in total output increases the importing country's welfare. In this situation, if firm 2 lowers its marginal cost through the R&D investment, then the less efficient firm 2's market share increases. To avoid this, the government of the importing country raises the external tariff if firm 2 engages in R&D. Under the FTA, a substitution effect of production occurs through the tariff level, a situation that does not arise under the uniform tariff policy. The effect of raising the tariff through the cost-reducing R&D investment becomes much larger under the FTA than under the uniform tariff. The formation of the FTA weakens the incentive for firm 2 to invest. On the contrary, it strengthens the incentive for the member country firm 1 because the FTA eliminates tariffs on the firm, negating the effect of increased tariff level through the cost-reducing R&D activity.

The difference between Hwang et al. (1997) and our analysis is as follows. They examine the discriminatory tariff, while we examine the FTA. The effect of increasing the tariff through R&D investment affects both firms under the uniform tariff, but it works only on the nonmember country firm under the FTA. While the technology with higher marginal cost is more likely to be chosen under the discriminatory tariff than under the uniform tariff (Hwang et al., 1997), both the higher and lower marginal cost technologies may be chosen under the FTA as compared with under the uniform tariff. In other words, if we consider the FTA as a measure of discriminatory tariff, then the lower marginal cost technology is more likely to be chosen under the FTA than under the uniform tariff policy.

4.5 Effect of FTA on the Importing Country's Welfare

The preceding section shows that the formation of an FTA may encourage adoption of the new technology by the exporting firms. We examine how the formation of an FTA affects the importing country's welfare. From Eqs. (4.1) through (4.10), the importing country's welfare with all patterns of technology choice under both the uniform tariff and the FTA is shown in Table 4.5.

First, we address the case when the FTA does not change the technology choice. From Table 4.5, changes in the importing country's welfare arising from the formation of an FTA are specified below:

$$\begin{aligned} W_3^{OO(FTA)} - W_3^{OO(UT)} &= -\frac{1}{44}(1-c)^2 < 0, \\ W_3^{NO(FTA)} - W_3^{NO(UT)} &= -\frac{1}{176}(4+4c-21c^2) < 0, \\ W_3^{NN(FTA)} - W_3^{NN(UT)} &= -\frac{1}{44} < 0, \end{aligned} \tag{4.11}$$

where OO (NN) denotes the case when both firms adopt the old technology (the new technology) and NO denotes the case when firm 1 adopts the new technology while firm 2 adopts the old technology. From Eq. (4.11), we obtain

Proposition 4.4 *When the formation of an FTA does not change the technology choice, it decreases the importing country's welfare.*

Second, we consider the case when the FTA changes the technology choice. From Table 4.5, changes in welfare arising from the formation of an FTA are specified below:

$$\begin{aligned} W_3^{NO(FTA)} - W_3^{OO(UT)} &= -\frac{1}{44}(1-10c-3c^2) > 0 \text{ if } c > \bar{c}, \\ W_3^{NO(FTA)} - W_3^{NN(UT)} &= -\frac{1}{44}(1+12c-8c^2) < 0, \\ W_3^{NO(FTA)} - W_3^{ON(UT)} &= -\frac{1}{176}(4+4c-21c^2) < 0, \end{aligned} \tag{4.12}$$

Table 4.5 Welfare level in importing country 3

Welfare	Uniform tariff policy	FTA
W_3^{OO}	$\frac{1}{4}(1-c)^2$	$\frac{5}{22}(1-c)^2$
W_3^{NO}	$\frac{1}{16}(2-c)^2$	$\frac{1}{22}(4c^2-6c+5)$
W_3^{ON}	$\frac{1}{16}(2-c)^2$	$\frac{1}{22}(3c^2-4c+5)$
W_3^{NN}	$\frac{1}{4}$	$\frac{5}{22}$

where $\bar{c} = \frac{1}{3}(5 - \sqrt{22}) \approx 0.103$. Note that *ON* denotes the case when firm 1 adopts the old technology, while firm 2 adopts the new technology. Here, we have

Proposition 4.5

(i) When the FTA encourages adoption of the new technology, it may increase the importing country's welfare.
(ii) When the FTA discourages adoption of the new technology, it decreases the importing country's welfare.
(iii) When the FTA counters the technology choice, it decreases the importing country's welfare.

Propositions 4.4 and 4.5 indicate that the formation of an FTA tends to decrease the importing country's welfare, regardless of whether the FTA changes technology choice. Only when the FTA encourages adoption of the new technology does it increase welfare if $c > \bar{c}$ holds.

Let us consider the logic behind Propositions 4.4 and 4.5. Suppose that the formation of an FTA does not change firms' technology choice. The formation of an FTA increases the member country firm 1's output and decreases the nonmember country firm 2's output through the strategic substitution effect. As a result, it increases total output because a direct effect on firm 1 dominates an indirect effect on firm 2. Thus, consumer surplus increases. However, the formation of an FTA eliminates the tariff on member firm 1 and tends to reduce the external tariff on nonmember firm 2. Then, tariff revenue decreases drastically. In this situation, the increase in consumer surplus does not compensate for the decrease in tariff revenue. That is why the formation of an FTA decreases the importing country's welfare when it does not change the technology choice.

The same logic applies to the case when the formation of an FTA changes the technology choice, except when the FTA encourages adoption of the new technology. In this case, the FTA drastically increases member firm 1's output through the elimination of tariffs as well as the unilateral adoption of new technology. However, the decrease in tariff revenue is not so large because both firms use the old technology under the uniform tariff. In this situation, the increase in consumer surplus can compensate for the decrease in tariff revenue. Thus, the formation of an FTA increases the importing country's welfare only when it encourages adoption of the new technology.

4.6 Concluding Remark

This chapter investigates how the formation of an FTA affects firms' technology choice (i.e., the cost-reducing R&D activities) as well as welfare in a three-country model where one importing country and two exporting countries exist. Our main conclusions are as follows: (i) The formation of an FTA strengthens the incentive for member country firm to invest and weakens the incentive for the nonmember country firm. (ii) The FTA may encourage or discourage adoption of the new technology by exporting firms. (iii) Only when the formation of an FTA encourages adoption of the new technology may it increase the importing country's welfare, while it tends to decrease welfare.

These results do not necessarily correspond to the results in Hwang et al. (1997), who did not examine the FTA but rather the discriminatory tariff regime, and showed that the discriminatory tariff induces adoption of technology with a higher marginal cost compared with the uniform tariff. This is because we assume the FTA as an extreme discriminatory tariff, taking into account the difficulty of implementing the discriminatory tariff among WTO member countries. Our findings imply that the formation of an FTA may encourage the firms' R&D activities depending on the effectiveness of cost-reducing R&D investment, in contrast to the results under the discriminatory tariff.

Future studies can extend this chapter in several directions. This chapter considers the formation of an FTA as a given. However, the voluntary formation of an FTA necessarily benefits all member countries. Therefore, it is desirable to investigate the condition for the endogenous formation of an FTA. It is also worthwhile to extend the duopoly model to an oligopoly one, as Elberfeld (2003) did.

Acknowledgements This work was supported by Grants-in-Aid for Scientific Research (no. 23530303, 26380340, and 26380318). All remaining errors are ours.

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Part II
The Timing of Trade Policies

Chapter 5
Endogenous Timing in Trade Policy Under the Three-Country Model

Takao Ohkawa, Makoto Okamura, and Makoto Tawada

Abstract This chapter provides a comprehensive and consistent explanation for the following result: a government with a smaller number of firms becomes a leader and provides a subsidy to home firms, whereas a government with a larger number of firms moves second and imposes a tax on domestic firms in the three-country model. This chapter also presents a comparison of the welfare of each country under free trade and under bilateral intervention, from which we derive policy implications.

Keywords Strategic trade policy • Endogenous timing • Strategic distortion • Terms of trade distortion • Welfare comparison

5.1 Introduction

The most familiar model used to tackle the analysis of government intervention in trade under imperfect competition is the three-country model initiated by Brander and Spencer (1985). It consists of two exporting countries lacking consumers and one importing country lacking producers, and international oligopoly arises in the market of the importing country. A number of studies have based their investigation on this model. For example, Krishna and Thursby (1991) and Van Long and Soubeyran (1997) considered how the curvature of the demand function and differences in the number of firms between the two exporting countries affect the level of subsidy. Dick (1993) examined the effect of trade policy in a case where cross-ownership exists. de Meza (1986) and Neary (1994) considered how cost asymmetry

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*,
New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_5

affects the different subsidy rates set by each exporting country's government. Cooper and Riezman (1989) and Hwang and Schulman (1993) analyzed the choice of policy instruments. Qiu (1994) incorporated asymmetric information on a firm's cost and examined the effect of this information on the optimal level of the subsidy.[1]

Though many researchers have examined various topics in the three-country framework "three-country" framework, they assume that each government intervenes simultaneously in trade. We therefore seek to determine whether the simultaneous policy decision by each government constitutes the equilibrium outcome in the three-country model. To our knowledge, few studies have investigated this problem.

Arvan (1991) and Shivakumar (1993) pointed out the possibility of sequential moves in the three-country model with incomplete information. Arvan (1991) introduced demand uncertainty into this model and argued the possibility of sequential play between governments. He identified the degree of demand uncertainty and the number of firms as key elements to determine the type of play. Shivakumar (1993) introduced an export quota as an additional instrument for governments but restricted the export competition to duopoly. Then, he established the conclusion that sequential play may occur when the export quota is chosen as a policy instrument and there is a high degree of uncertainty. In these studies, the decision about the timing of bilateral government intervention is deeply connected with the degree of uncertainty.

Ohkawa et al. (2002) examined an endogenous timing game in the three-country model *without* uncertainty. Using Theorem 5, Hamilton and Slutsky (1990) established that if there is a different number of firms between two exporting countries, then the government of the country with fewer firms becomes a first mover and subsidizes its home firms. By contrast, the government of the country with the larger number of firms acts as a second mover and imposes an export tax on its firms; otherwise, both governments set positive subsidy rates simultaneously.[2] However, they did not succeed in properly explaining why the difference in the number of firms has the abovementioned effect on endogenous timing.

The purpose of this chapter is to try to provide a comprehensive and consistent explanation for the above results. To this end, we compare the optimal subsidy rate in the simultaneous move case with that in the sequential case. We explain the differences in the rates of subsidies in the two cases using two distortions and associated marginal change: the terms of trade distortion and the strategic distortion, which are introduced by Krishna and Thursby (1991). We connect these distortions and their marginal change with the differences in the number of firms between two countries. We also explain endogenous timing from the viewpoint of the first- and

[1] Brander (1995) surveys strategic trade policy.

[2] In other frameworks dealing with trade policy games, several researchers treating the problem of the endogenous timing game between governments also concluded that the simultaneous move setting is not always appropriate, e.g., Syropoulos (1994) and Collie (1994).

second-mover advantages, which is connected with the number of firms between two countries.

Another purpose of this chapter is to compare the welfare of each country under free trade and under bilateral intervention. We present a policy implication following Bliss (1996) observes that industrial or antitrust policies in exporting countries affect the welfare of the third country, because these domestic policies influence the market structure (the number of firms) of the exporting countries. Our results also suggest that, depending on the number of firms, one of the exporting countries may adopt an export tax rather than a subsidy. Thus, the strategic trade policies of the exporting countries decrease the welfare of the third country. The WTO cannot directly intervene in the content of industrial and antitrust policies in each member country. It prohibits export subsidies but does not prohibit export taxes. These features suggest that each member country should consider policy harmonization between domestic public policies and trade policies with each other, and the WTO needs to discuss the restriction on export taxes as well as subsidies. The chapter is organized as follows: Sect. 5.2 presents a multistage game to analyze the timing of policy setting. In Sect. 5.3, we solve this game using subgame perfection as a solution concept. Section 5.4 shows the main results and provides the comprehensive explanation for why our results constitute an equilibrium. In Sect. 5.5, we compare the equilibrium level of welfare under free trade and bilateral intervention. Section 5.6 contains the main conclusions, and Sect. 5.6 provides the mathematical appendices used in this study.

5.2 The Model

Consider a world economy where three countries (the first, second, and third countries) and one commodity exist. The commodity is produced in the first and second countries and exported to the third country without any consumption in the producing countries. There are n_i firms located in the country i, for $i = 1$ and 2. Each firm has identical production technology with constant returns to scale. Unit cost can be denoted by c.

In the third country, there is no production, and consumers purchase the commodity imported from the first and second countries. Let the inverse demand function of the third country be $p = p(Q) \equiv A - Q$, where Q is the demand for the commodity, p is the commodity price, and A is a positive parameter expressing a market scale and assumed to be greater than c. Each firm competes *à la* Cournot in the third country market.

The government of each exporting country subsidizes exports of its home firms so as to maximize the country's national welfare. Each government chooses not only the level of the subsidy s_i but also the timing of the policy intervention. The government of the third country does not consider any policies on trade.

To examine the conventional assumption of a simultaneous move in the game of government intervention, we construct the following multistage game. In the first stage, the government of each producing country chooses the timing of setting the level of its export subsidy, namely, the first move or the second move. If both governments move at the same time, then the timing is said to be simultaneous. Otherwise, it is said to be sequential. In the second stage, each government chooses the level of its export subsidy according to the timing.[3] Once each government sets the level of subsidy, all identical firms produce the commodity and export it to the third country under Cournot competition in the third stage. We introduce the subgame perfect Nash equilibrium as a solution to solve the above multistage game.

5.3 The Analysis

5.3.1 Stage 3 Subgame

Let us begin with the third stage subgame. The profit of country i's firm k is given by

$$\pi_{ik} = (p(Q) - c)q_{ik} + s_i q_{ik}, \tag{5.1}$$

where q_{ik} is an individual output of country i's firm $k(= 1, \ldots, n_i)$. From (5.1), the first-order condition for profit maximization is given by

$$p'(Q)q_{ik} + p(Q) - c + s_i = 0. \tag{5.2}$$

We have the semi-symmetric Cournot equilibrium, which means that the level of output of each firm located in the same country is identical, i.e., $q_{ik} = q_i$. We can transform (5.2) into

$$(n_i + 1)q_i + n_j q_j = A - c + s_i, \quad (i, j) = 1, 2), i \neq j. \tag{5.3}$$

From (5.3) we have the semi-symmetric Cournot equilibrium output level of each firm in country i, i.e.,

$$q_i = \frac{a + (n_j + 1)s_i - n_j s_j}{N}, \tag{5.4}$$

where $N \equiv n_i + n_j + 1$ and $a \equiv A - c > 0$. We also obtain the equilibrium total output $Q = Q_i + Q_j = n_i q_i + n_j q_j$ as

$$Q = \frac{(N - 1)a + n_i s_i + n_j s_j}{N}. \tag{5.5}$$

[3]This type of timing game is called an observable delay; see Hamilton and Slutsky (1990).

The subsidy's effects on Q_i and Q are derived from (5.4) and (5.5):

$$\frac{\partial Q_i}{\partial s_i} = \frac{n_i(n_j + 1)}{N} > 0, \tag{5.6}$$

$$\frac{\partial Q_i}{\partial s_j} = \frac{n_i n_j}{N} < 0. \tag{5.7}$$

and

$$\frac{\partial Q}{\partial s_i} = \frac{n_i}{N} > 0. \tag{5.8}$$

These results state that s_i increases (decreases) aggregate outputs of country i's firms (country j's firms), and the direct effect shown in (5.6) dominates the indirect effect shown in (5.7). They also state that s_i increases total output.

Substituting (5.4) and (5.5) into (5.1) yields the equilibrium profit, π_i as

$$\pi_i = (P(Q) - c)q_i + s_i q_i = q_i^2. \tag{5.9}$$

5.3.2 *Stage 2 Subgame*

In the second stage, with the other country having given its subsidy, the government of country i, $i=1,2$, tries to set the level of subsidy s_i in order to maximize its national welfare, which is denoted by W_i and defined as the sum of firms' profits and subsidy payments. From (5.4) and (5.9), the following is derived:

$$W_i = W_i(s_i, s_j) = n_i\pi_i - n_i s_i q_i = (p(Q) - c)Q_i, \tag{5.10}$$

where $Q_i = n_i q_i$. Two possible cases occur at this stage: (1) Each government simultaneously sets its level of subsidy. (2) One government moves first (chooses its subsidy rate). After observing this rate, the other government sets its subsidy. In this case, one government plays the role of a leader and the other a follower.

5.3.2.1 Simultaneous Move

We consider the case of simultaneous moves. Government i tries to set its subsidy rate s_i to maximize its national welfare, given the other country's subsidy s_j and foreseeing the third stage equilibrium $q_i(s_i, s_j)$, $(i,j) = (1,2)$. The government solves the following problem

$$\max_{s_i} . W_i(s_i, s_j). \tag{5.11}$$

The first-order condition for the problem (5.11) is given by

$$\frac{\partial W_i(s_i, s_j)}{\partial s_i} = (p(Q) - c)\frac{\partial Q_i}{\partial s_i} + p'(Q)Q_i\frac{\partial Q}{\partial s_i} = 0. \tag{5.12}$$

The first term on the right-hand side (RHS) of (5.12) shows the marginal welfare benefit of a country's output expansion caused by subsidy. The second term shows the marginal cost of welfare through market price reduction caused by subsidy. From (5.12), we can derive a reaction function of the government i with respect to each subsidy.

$$s_i = r_i(s_j) = -\frac{n_j(n_j + 1 - n_i)}{2n_i(n_j + 1)} \cdot s_j + \frac{(n_j + 1 - n_i)}{2n_i(n_j + 1)}a. \tag{5.13}$$

$$s_j = r_j(s_i) = -\frac{n_i(n_i + 1 - n_j)}{2n_j(n_i + 1)} \cdot s_i + \frac{(n_i + 1 - n_j)}{2n_j(n_i + 1)}a. \tag{5.14}$$

We obtain the following slope of the reaction function.[4]

Lemma 5.1

(1) If $n_i \geq n_j + 2$ ($n_j \geq n_i + 2$), then the slope of country i's (country j's) reaction function is positive. Strategic complementarity prevails.
(2) If $n_i = n_j + 1$ ($n_j = n_i + 1$), then the slope of country i's (country j's) reaction function is flat. Strategic independence prevails.
(3) If $n_i \leq n_j$ ($n_j \leq n_i$), then the slope of country i's (country j's) reaction function is positive. Strategic substitutability prevails.

Roughly speaking, Lemma 5.1 states that when the number of firms in a concerned country is larger (smaller) than that in a rival country, the reaction function for the concerned country's subsidy rate is upward (downward) sloping.

We can obtain the equilibrium subsidy level of each government, denoted by s_i^C, i.e.,

$$s_i^C = \frac{(n_j + 1 - n_i)}{n_i(N + 2)}a \tag{5.15}$$

By solving (5.13) and (5.14), we obtain the following result.

Lemma 5.2 *Suppose that both exporting countries' governments set their subsidy levels simultaneously.*

(1) If $n_i \geq n_j + 2$, then country i's government imposes taxes on its firms.
(2) If $n_i = n_j + 1$, then it does not intervene at all.
(3) If $n_i \leq n_j$, then it subsidizes its firms.

[4] See Appendix A for derivation.

The resulting levels of national welfares $W_i^C = W_i(s_i^C, s_j^C)$ are given by[5]

$$W_i^C = W_i(s_i^C, s_j^C) = \frac{n_j + 1}{(N+2)^2} a^2. \tag{5.16}$$

5.3.2.2 Sequential Move

Let us investigate the sequential move case. We assume that government i is a leader, while government $j (\neq i)$ plays a follower. The government sets its subsidy level s_i optimally, taking into account the rival's response (5.14). It solves the problem

$$\max_{s_i} W_i = W_i\left(s_i, r_j(s_i)\right). \tag{5.17}$$

The first-order condition for welfare maximization is

$$\frac{\partial W_i\left(s_i, r_j(s_i)\right)}{\partial s_i} + \frac{\partial W_i\left(s_i, r_j(s_i)\right)}{\partial s_j} r_j'(s_i) = 0, \tag{5.18}$$

which is rewritten as

$$\begin{aligned}(p(Q) - c)\frac{\partial Q_i}{\partial s_i} &+ p'(Q)Q_i\frac{\partial Q}{\partial s_i} \\ &+ (p(Q) - c)\frac{\partial Q_i}{\partial s_j} r_j'(s_i) + p'(Q)Q_i\frac{\partial Q}{\partial s_j} r_j'(s_i) = 0. \end{aligned} \tag{5.19}$$

The first term (the second term) on the left-hand side (LHS) of (5.19) is the same as the first one (the second one) of (5.12). These are direct effects, whereas the third and fourth terms of (5.19) are indirect effects. The third term represents a change in the level of leader i's welfare through the follower's best response to the leader's subsidy level. The fourth one shows the change in the level of leader i's welfare caused by price change through the follower's best response.

From (5.19), we have the optimal subsidy level, s_i^L, i.e.,

$$s_i^L = \frac{1}{n_i(n_i + 2)} a. \tag{5.20}$$

From (5.20) and $s_j = r_j(s_i)$, we derive

$$s_j^F = \frac{n_i + 1 - n_j}{2n_i(n_i + 2)} a. \tag{5.21}$$

[5] See Appendix B for derivation.

From (5.20) and (5.21), we have

Lemma 5.3 *Suppose that government i becomes a leader and government j becomes a follower.*

(1) The leader government i always subsidizes its firms.
(2) The follower government j imposes a tax on its firms if $n_j > n_i + 1$; it does not intervene at all if $n_j = n_i + 1$, and it subsidizes its firms if $n_j < n_i + 1$.

From (5.20) and (5.21), we also have the resulting welfare level of each country W_i^L and W_j^F as follows[6]:

$$W_i^L = W_i(s_i^L, s_j^F) = \frac{1}{4(n_i + 2)} a^2, \tag{5.22}$$

$$W_j^F = W_j(s_j^F, s_i^L) = \frac{n_i + 1}{4(n_i + 2)^2} a^2. \tag{5.23}$$

5.3.3 Stage 1 Subgame

We return to the first stage. Each government chooses to become either a leader, denoted by L, or a follower, denoted by F. We assume that a simultaneous game occurs if both firms move first or second. The 2×2 payoff matrix in Table 5.1 summarizes this situation.

From (5.16), (5.22), and (5.23), we establish the following result.[7]

Lemma 5.4 *Suppose that (S_1, S_2) denotes the equilibrium pair of strategies that country i's government selects, $S_i \in \{L, F\}$.*

(1) If $n_1 \leq n_2 - 2$, then (L, F) emerges.
(2) If $n_1 = n_2 - 1$, then either (L, L) or (L, F) emerges.
(3) If $n_1 = n_2$, then (L, L) is an equilibrium pair of strategies.
(4) If $n_1 = n_2 + 1$, then either (L, L) and (F, L) occurs.
(5) If that $n_1 \geq n_2 + 2$, then (F, L) occurs.[8]

Table 5.1 Stage 1 subgame

Country 1 \ Country 2	L	F
L	W_1^C, W_2^C	W_1^L, W_2^F
F	W_1^F, W_2^L	W_1^C, W_2^C

[6]See Appendix C for derivation of s_i^L, s_j^F, W_i^L, and W_j^F.

[7]Ohkawa et al. (2002) proved this result using Theorem 5 in Hamilton and Slutsky (1990).

[8]See Appendix D for the proof of this result.

5.4 Main Results

5.4.1 Comparison Among Subsidy Rates

First, we compare the equilibrium subsidy rate in the cases of simultaneous and sequential moves. From (5.15), (5.20), and (5.21) and Lemmas 5.2 and 5.3, we establish

Proposition 5.1 *Suppose that country i's government becomes a leader and country j's a follower in the sequential case.*

(1) $n_i \geq n_j + 2$, *then* $s_i^L > 0 > s_i^C$ *and* $s_j^C > s_j^F > 0$.
(2) $n_i = n_j + 1$, *then* $s_i^L > 0 = s_i^C$ *and* $s_j^C > s_j^F > 0$.
(3) If $n_i = n_j$, *then* $s_i^L > s_i^C > 0$ *and* $s_j^C > s_j^F > 0$.
(4) If $n_i = n_j - 1$, *then* $s_i^L = s_i^C > 0$ *and* $s_j^C = s_j^F = 0$.
(5) If $n_i \leq n_i - 2$, *then* $s_i^C > s_i^L > 0$ *and* $0 > s_j^C > s_j^F$.[9]

We will try to explain why the concerned country i's government sets a positive (negative) subsidy rate when it has fewer (more) firms than country j in the case with simultaneous moves. Following Krishna and Thursby (1991), we can rearrange (5.12) by considering $p - c = -p' \frac{Q_i}{n_i} - s_i$ from (5.2) as

$$s_i^C = p' Q_i \left(1 - \frac{1}{n_i}\right) + p' Q_i \cdot \frac{\frac{\partial Q_j}{\partial s_i}}{\frac{\partial Q_i}{\partial s_i}} \tag{5.24}$$

The sign of the first term is negative unless $n_i = 1$; the sign of the second term is positive from (5.6) and (5.7). The first term on the RHS of (5.24) shows a negative effect on country i's domestic welfare because of the price reduction through output expansion of domestic firms i caused by subsidization. This negative effect is referred to as *the terms of trade distortion*. The second term, called *the strategic distortion*, shows a positive effect on the rival firms' output shrinkage through the production substitution between country i's domestic firms and foreign firms caused by subsidization. Thus, if the terms of trade distortion dominate (are dominated by) the strategic distortion in country i, then government i sets a negative (positive) subsidy rate in the case with simultaneous moves. An increase in the number of country i's firms enhances the degree of the terms of trade distortion in country i. However, an increase in the number of country j's firms raises the degree of the strategic distortion in country i.

Thus, we establish

[9]See Appendix E for the proof of Proposition 5.1.

Result 5.1 *In country i, if $n_i \leq n_j$, then the terms of trade distortion are dominated by the strategic distortion, resulting in $s_i^C > 0$*[10]*; otherwise, the former is not dominated by the latter, resulting in $s_i^C \leq 0$.*

Next we explain the results of the comparison between s_i^L and s_i^C. Using (5.24), we can rearrange (5.19) as

$$s_i^L = p'Q_i\left(1 - \frac{1}{n_i}\right) + p'Q_i \cdot \frac{\frac{\partial Q_j}{\partial s_i}}{\frac{\partial Q_i}{\partial s_i}} + \frac{\frac{\partial W_i(s_i, r_j(s_i))}{\partial s_j} r_j'(s_i)}{\frac{\partial Q_i}{\partial s_i}}, \tag{5.25}$$

where

$$\frac{\partial W_i(s_i, s_j)}{\partial s_j} = (p - c)\frac{\partial Q_i}{\partial s_j} + p'Q_i\frac{\partial Q}{\partial s_j} < 0. \tag{5.26}$$

The first and the second terms on the RHS of (5.25) are the same as the first and the second terms of the RHS on (5.24). The third term shows that each country suffers a welfare loss if the rival country increases its subsidy (decreases its tax). In other words, each country favors a lower rate of subsidy (higher rate of tax) by the rival country. Becoming a leader enables country *i*'s government to reduce the subsidy rate. Therefore, the third term is called *the first-mover advantage*.

The sign of the term shown as the first-mover advantage depends on the sign of the slope of the reaction function of country *j*'s firm. If $r_j'(s_i) < (>)0$, then the first-mover advantage is positive (negative). This means that when $r_j'(s_i) < (>)0$, leader country *i*'s government can improve its welfare via a decrease in rival country *j*'s subsidy rate by increasing (decreasing) its subsidy rate. Therefore, leader government *i* should set a higher (lower) subsidy rate in the case with sequential moves, while government *i* does so in the simultaneous case. Thus, we establish

Result 5.2 *If $r_j'(s_i) < (>)0$, then $s_i^L > (<)s_i^C$.*

Let us examine the relationship between the different number of firms and the slope of the reaction function of government *j*, $r_j'(s_i)$. From (5.12), we can derive the slope of country *j*'s reaction function as

$$r_j'(s_i) = -\frac{\frac{\partial^2 W_j}{\partial s_j \partial s_i}}{\frac{\partial^2 W_j}{\partial s_j^2}} \tag{5.27}$$

Since the denominator on the RHS of (5.27) is negative, the sign of the numerator $\frac{\partial^2 W_j}{\partial s_j \partial s_i}$ determines the sign of $r_j'(s_i)$. This shows the change in country *j*'s marginal

[10]Note that government *i* always subsidizes its firms when $n_i = 1$ in the simultaneous move because terms of trade distortion vanishes.

benefit resulting from its subsidy rate. From (5.12), this is given by

$$\frac{\partial^2 W_j}{\partial s_j \partial s_i} = p' \frac{\partial Q_j}{\partial s_j}\frac{\partial Q}{\partial s_i} + p'\left(\frac{\partial Q_i}{\partial s_j} + \frac{\partial Q_j}{\partial s_j}\right)\frac{\partial Q_j}{\partial s_i}$$
$$\propto p'\left(\frac{\partial Q}{\partial s_i} + \frac{\partial Q_j}{\partial s_i}\right) + p'\frac{\frac{\partial Q_i}{\partial s_j}}{\frac{\partial Q_j}{\partial s_j}}\frac{\partial Q_j}{\partial s_i}. \quad (5.28)$$

The first term in the bracket on the RHS of (5.28) means that an increase in the subsidy rate of country i relaxes the terms of trade distortion in country j. The increase brings about the shrinkage of the total output of country j's firms Q_j via production substitution. Since this shrinkage decreases the degree of price reduction, it relaxes the terms of trade distortion in country j. Therefore, we call the first term *the relaxing effect of the terms of trade distortion* in country j, which is nonnegative.[11]

The second term shows that an increase in s_i deteriorates the strategic distortion in country j. The shrinkage of Q_j through product substitution caused by this increase decreases price reduction, so that this decrease is beneficial for each firm in country i. Each firm can limit its output reduction in response to the increase in Q_j caused by the subsidization by country j's government. The second term, therefore, is called *the deteriorating effect of the strategic distortion* in country j, which is negative.

Note that in country j, an increase in n_j enhances the relaxation effect of the terms of trade distortion, whereas an increase in n_i raises the deteriorating effect of the strategic distortion. From (5.14) and (5.28), we obtain

Result 5.3 *If $n_i \neq n_j + 1$, then the slope of $r_j(s_i)$ is nonnegative because the relaxation effect of the terms of trade distortion is outweighed by the deteriorating effect of strategic distortion in country j. Otherwise, the slope of $r_j(s_i)$ is negative because the relaxation effect outweighs the deteriorating effect in country j.*

From Results 5.1, 5.2, and 5.3 we derive the following: Suppose that $n_i > n_j$. Then, in the simultaneous move case, the terms of trade distortion are (not) dominated by the strategic distortion in country j (i), so that country j's (country i's) government sets a positive (nonpositive) subsidy rate. Next, the relaxation effect of the terms of trade distortion is outweighed by the deteriorating effect of the strategic distortion in country j, which implies that follower government j reduces its rate of subsidy in response to the increase in s_i. The decrease in s_j caused by the increase in s_i is beneficial for the leader government i. This is the first-mover advantage. Since both the positive first-mover advantage and strategic distortion dominate the terms of trade distortion in country i, leader government i sets its positive subsidy rate. Thus, when $n_i > n_j$, $s_i^L > 0 \geq s_i^C$ and $s_j^C \geq s_j^F > 0$.

[11] We derive $p'(\frac{\partial Q}{\partial s_i} + \frac{\partial Q_j}{\partial s_i}) = \frac{p'}{N} n_i(n_j - 1) \geq 0$ from (5.4) and (5.5).

Suppose that $n_i = n_j$. Then the terms of trade distortion is dominated by the strategic distortion in both countries, so that each of them sets a positive subsidy rate in the simultaneous move. Next, the relaxation effect of the terms of trade distortion is outweighed by the deteriorating effect of the strategic distortion in country j, the leader government improves its welfare by increasing s_i. Since both positive first-mover advantage and strategic distortion dominate the terms of trade distortion in country i, the leader government i sets its positive subsidy rate. Thus, when $n_i > n_j$, $s_i^L > s_i^C > 0$ and $s_j^C > s_j^F > 0$.

If $n_i < n_j$, then the terms of trade distortion dominate (are dominated by) the strategic distortion in country j (i), so that country j's (i's) government sets a negative (positive) subsidy rate in the simultaneous move. The relaxation effect of the terms of trade distortion outweighs the deteriorating effect of the strategic distortion in country j, which implies that the follower government j reduces its rate of subsidy in response to the reduction in s_i. The decrease in s_j caused by the reduction in s_i is beneficial for leader government i. This is the first-mover advantage. Since strategic distortion dominates both the negative first-mover advantage and the terms of trade distortion in country i, leader government i sets a positive subsidy rate. Thus, when $n_i > n_j$, $s_i^C > s_i^L > 0$, and $0 > s_j^C > s_j^F$.

5.4.2 Endogenous Timing

We establish the following result about endogenous timing of subsidy from Lemmas 5.2, 5.3, and 5.4.

Proposition 5.2 (Proposition 1 in Ohkawa et al. (2002))

(1) Suppose that there is the same number of firms in both export countries, i.e., $n_1 = n_2$; then the timing of decisions is simultaneous. Both governments subsidize their home firms.

(2) Suppose that the difference in the number of firms between countries is just 1, i.e., $n_1 = n_2 + 1$ or $n_2 = n_1 + 1$. Then the timing of decision is uncertain in the sense that the government of the country with the larger number of firms does not take any action regardless of the other government's strategy. The government of the country with fewer firms subsidizes its home firms, while the optimal strategy of the other government is nonintervention.

(3) Suppose that the difference in the number of firms between countries is more than 1, i.e., $n_1 \geq n_2+2$ or $n_2 \geq n_1+2$. Then the timing of decision is sequential. The government of the country with fewer firms acts as a leader and subsidizes its home firms, while the other government acts as a follower and imposes an export tax on its home firms.

Proposition 5.2 states that if the number of firms in both country is the same, then the timing of subsidization is simultaneous; otherwise, it is sequential in the sense that the country with a smaller (larger) number of firms acts as a leader (a follower) and sets a positive (negative) subsidy rate.[12] Proposition 5.2 demonstrates that the simultaneous move of bilateral governments is not general. The only exception is the case where the number of firms is identical between export countries. This implies that many previous studies based on the assumption of simultaneous moves need to be reexamined.

We explain these results. Suppose that $n_i = n_j$. When rival country j's government chooses the strategy F, the concerned country i's government obtains a more advantageous position by changing its choice from F to L because a leader can control a rival's subsidy rate indirectly, as shown in the second term of (5.25). Since the rival j's reaction function is downward sloping in Result 5.3, leader country i can reduce s_j by increasing s_i.

When the rival country j's government chooses strategy L, concerned country i's government selects L. Otherwise, leader country j sets a higher rate of subsidy to decrease s_i indirectly, because the slope of government i's reaction function is negative from Result 5.3. This results in the reduction of the level of country i's welfare. Therefore, L is a dominant strategy for county i. This result holds in the rival country. Thus, both governments choose L, which results in simultaneous timing.

Suppose that $n_i < n_j$. When rival country j's government chooses strategy F, country i's government chooses L to obtain the first-mover advantage. Since the rival j's reaction function is upward sloping in Result 5.3, leader country i can improve its welfare by reducing s_j in response to the reduction of s_i.

When rival country j's government chooses strategy L, country i's government chooses L. Otherwise, the leader j sets a higher subsidy rate to decrease s_i indirectly, because the slope of government i's reaction function is negative from Result 5.3. This is harmful for country i's welfare. Therefore, L is a dominant strategy for county i.

When country i's government chooses L, which does country j's government choose, L or F? Country j's government chooses F. If so, then the leader government i decreases s_i in order to reduce s_j. The decrease in s_i is beneficial for country j's welfare.

5.5 Free Trade vs. Bilateral Intervention

In this subsection, we compare the level of each country's welfare under bilateral government intervention with that of free trade. We define the third country's welfare as consumer surplus, so that it is expressed as

$$W_3 \equiv \int_0^Q P(x)dx - P(Q)\,Q = \frac{1}{2}Q^2. \tag{5.29}$$

[12] Arvan (1991) obtained similar results but did not explain clearly why these outcomes occur.

We calculate the level of each country's welfare under free trade by setting $s_1 = s_2 = 0$. From (5.4), (5.5), (5.10), and (5.29), these are given by

$$W_i^{FT} = \frac{n_i}{N^2}a^2, \quad i = 1, 2, \tag{5.30}$$

$$W_3^{FT} = \frac{(N-1)^2}{2N^2}a^2, \tag{5.31}$$

where the superscript *FT* stands for free trade.

Next, we calculate the welfare of the third country under intervention. We assume that country *i*'s government becomes a leader in the sequential move. In the case of simultaneous moves, we can derive from (5.29) and (B5.5)

$$W_3^C = \frac{(N+1)^2}{2(N+2)^2}a^2. \tag{5.32}$$

In the case of sequential moves, however, we can obtain from (5.29) and (C5.7)

$$W_3^{LF} = \frac{(2n_i+3)^2}{2[2(n_i+2)]^2}a^2. \tag{5.33}$$

Considering endogenous timing of subsidization shown in Proposition 5.2, we compare welfare under free trade and bilateral intervention. From (5.16), (5.22), (5.23), (5.30), (5.31), (5.32) and (5.33), we establish

Proposition 5.3

(1) Suppose that $n_i = n_j$; then the timing of subsidization is a simultaneous move. For an exporting country i, welfare under bilateral intervention is smaller than under free trade. Suppose that $n_j \geq n_i + 1$. Then, the timing of subsidization is a sequential move led by leader government i. Leader country i's welfare under bilateral intervention is greater than that under free trade.

(2) Suppose that $\rho(n_i) > n_j \geq n_i + 1$ ($n_j \geq \rho(n_i)$). Note that $\rho(n_i)$ is a finite critical value. Then, the timing is a sequential move with leader government i as the first mover. Follower country j's welfare under bilateral intervention is (not) smaller than under free trade.

(3) Suppose that $n_i + 3 > n_j \geq n_i$ ($n_j \geq n_i + 3$). Then the welfare of the importing country under bilateral intervention is (not) larger than that under free trade.[13]

These results can be explained as follows: In the choice of a strategic trade policy, our assumptions of linear demand and identical unit cost enable each exporting country's government to act as if there were a single firm in each country, whatever the actual number of firms. Once the subsidy and the profit of this fictitious firm are set at the optimal levels, then these are equally shared among the actually existing firms in each country.

[13] See Appendix F for the proof.

Now, keeping this in mind, we suppose that the government of country *j* acts as a follower, while government *i* acts as a leader in policy setting. Then, country *i*'s government can control the level of production in the second country. In so doing, country *i*'s government regards country *j* as if it has only one firm. Hence, the total profit of the second country, which is guided by government *i* under the supposition that only one firm operates in country *j*, is determined only by the number of firms in the country *i*, as is the welfare level of country *j*. In the Stackelberg situation, the number of firms in country *j* is not related to the determination of its welfare level. This argument is supported by the fact that the number of firms in the second country n_j does not appear in (5.22) and (5.23).

However, without government intervention, the exporting country's welfare decreases as the number of firms in a concerned country increases. Therefore, welfare in country *j* may be higher under government intervention than under free trade if the number of firms in country *j* becomes sufficiently large relative to that in country *i*.

We now turn our attention to the third importing country's welfare. In view of the above discussion, we should notice that each country's welfare is not affected by the number of firms in country *j* in the case of sequential moves. However, under free trade, the welfare of each producing country falls, and the welfare of the third country rises as the number of firms increases. As a result, an increase in the number of firms in country *j* reduces the welfare level of the third country under government intervention; thus, if the increase is sufficiently large, the welfare of the third country tends to be lower than that under free trade.

These results indicate the following implications for the WTO. First, the difference in the number of firms between two exporting countries influences the welfare of the importing country. This means that the welfare of the importing country may be indirectly affected through trade by industrial policies, such as an antitrust policy and entry regulation, which can control the number of firms in an exporting country. For example, if the antitrust policy of country *i* is not strict against horizontal mergers, while that of country *j* is quite rigorous, then the number of firms in country *i* may be sufficiently smaller than that in the country *j*. As a result, bilateral intervention harms the third importing country's welfare. Harmonization of trade policies with domestic public ones is necessary to protect the benefits of consumers in the importing country.

Regarding export taxes, the WTO does not rigorously discuss them. This is because it is considered that an exporting country does not have a strong incentive to use export taxes in the promotion of trade. Contrarily, our results suggest that it is possible for a country with a larger number of firms to strategically choose an export tax. In our framework, the export tax is detrimental to the third country's welfare; therefore, in this case, we need to consider export taxes in trade negotiation.

Finally, we turn our attention to world welfare. World welfare is described as

$$W^k = \Sigma_{i=1}^{3} W_i^k, k = FT, C, LF \tag{5.34}$$

From (5.16), (5.22), (5.23), (5.30), (5.31), (5.32), and (5.33), we obtain

$$W^{FT} = \frac{N^2 - 1}{N^2} a^2, \tag{5.35}$$

$$W^{C} = \frac{(N+2)^2 - 1}{2(N+2)^2} a^2, \tag{5.36}$$

$$W^{LF} = \frac{[2(n_i+2)]^2 - 1}{2[2(n_i+2)]^2} a^2. \tag{5.37}$$

From (5.35), (5.36), and (5.37), we establish

Proposition 5.4 (Proposition 3 in Ohkawa et al. (2002)) *If the difference between the number of exporting countries' firms is less (more) than three, then world welfare is better (worse) off under trade intervention than under free trade. If the difference is by only three, then world welfare is not affected by trade intervention.*[14]

We derive one implication from this proposition. Though it is believed that for some countries free trade is not preferable under imperfect competition and that it is reasonable for countries to use strategic trade policies, free trade may be better than trade intervention from the view of world trade. This is particularly true in the case where market size sufficiently differs between exporting countries. Therefore, it is important for the WTO to promote free trade on the one hand and to adjust the benefits from free trade among trading countries on the other, even if the market obeys imperfect competition.

5.6 Conclusion and Remarks

Ohkawa et al. (2002) constructed a three-country model in which oligopolistic firms located in two countries export a homogeneous product to the third country's market, and two exporting countries' governments intervene in the market using an export subsidy (tax). They established that the government of the small country chooses to be a first mover and subsidizes its home firms, while the government of the large country becomes a second mover and imposes an export tax on its firms. We have investigated the economic explanation for why these results occur from the standpoint of the differences in the number of firms between two exporting countries, and we conclude as follows.

Suppose that $n_i = n_j$. Since the relaxing effect of the terms of trade distortion dominates the deteriorating effect of strategic distortion for both exporting countries, leader country i could reduce s_j by increasing s_i. This is beneficial for the leader country's welfare. Thus, both governments seek to become a leader, and the timing of trade policy is simultaneous.

[14]See Appendix G for the proof.

Suppose that $n_i < n_j$. Given that the relaxing effect of the terms of trade distortion is dominated by the deteriorating effect of strategic distortion for country j, leader country i could reduce s_j by decreasing s_i, which is beneficial for country i. The decrease in s_i is also beneficial for country j, which is an incentive to become a follower. Country i with fewer firms becomes a leader, while country j with more firms becomes a follower. Thus, the timing is sequential.

We now compare the welfare of each country under free trade and bilateral intervention. We establish the following: Suppose that $n_i \leq n_j$. If the differences in the number of firms between two exporting countries are large, then the level of welfare in each exporting country under bilateral intervention is greater than that under free trade, and then the level of welfare in the third importing country under bilateral intervention is smaller than that under free trade. If the differences are very small, then the welfare of both exporting country i and that of the importing country under bilateral intervention is larger than under free trade and then that of country j under bilateral intervention is smaller than under free trade.

Several implications are derived from our results. First, as long as the number of firms differs between exporting countries, the governments move sequentially. We therefore need to rigorously investigate the bilateral intervention described by the sequential move game rather than that by the simultaneous move one in the analysis of strategic trade policies. Second, the difference in the number of firms is crucial to each exporting country's policy and welfare. Since domestic public policies can influence the number of domestic firms, those policies should be taken into account at the table of the WTO. Third, in our framework, an export tax is a possible choice for a large country. Export taxes are usually considered to harm the consumer surplus of importing countries since it raises the international price. Hence, careful attention should be paid to export taxes as well as export subsidies in trade negotiation. Finally, for world welfare, free trade is better than trade intervention, even under imperfect competition, if the difference in the number of firms exceeds 3 in degree between exporting countries. In this case, there is no reason to support strategic trade policies from the world welfare point of view. Hence, the WTO should promote free trade even under imperfect competition and adjust each country's gain and loss from free trade by some instruments.

Acknowledgements This chapter is a revised version of Ohkawa et al. (2002). We appreciate that Edward Elgar gave me permission to reuse our volume. This work was supported by Grants-in-Aid for Scientific Research (no. 23530303 and 26380340). All remaining errors are ours.

Appendix

A Derivation of (5.13)

Considering $\frac{\partial Q_i}{\partial s_i} = n_i \frac{\partial q_i}{\partial s_i} = \frac{n_i(n_j+1)}{N}$ derived from (5.4) and $\frac{\partial Q}{\partial s_i}$ derived from (5.5), we can rewrite (5.12) as

$$\left(a - \frac{(N-1)a + n_i s_i + n_j s_j}{N}\right) \cdot \frac{n_i(n_j+1)}{N} - \frac{n_i(a + (n_j+1)s_i - n_j s_j}{N} \cdot \frac{n_i}{N} = 0. \tag{A5.1}$$

Rearranging terms on (A5.1) yields

$$(n_j + 1 - n_i)a - 2n_i(n_j+1)s_i - n_j(n_j + 1 - n_i)s_j = 0. \tag{A5.2}$$

Therefore, we can easily obtain (5.13) from (A5.2). We can also obtain (5.14) by a similar calculation.

B Derivation of s_i^C and W_i^C

Substituting $s_j = r_j(s_i)$ into the first term on the RHS of (5.15) yields

$$s_i = \frac{n_j - n_i + 1}{2n_i(n_j+1)}\left[a - n_j \frac{(a - n_i s_i)(n_i - n_j + 1)}{2n_j(n_i+1)}\right]. \tag{B5.1}$$

After some manipulations, (B5.1) becomes

$$s_i = \frac{N(n_j - n_i + 1)}{n_i \Phi_B} a, \tag{B5.2}$$

where

$$\Phi_B = 3(n_1+1)(n_2+1) + \sum_{i=1}^{2} n_i(n_i+1) - n_1 n_2.$$

Rearranging Φ_B, we obtain

$$\begin{aligned} \Phi_B &= n_1^2 + n_2^2 + 2n_1 n_2 + 4(n_1 + n_2) + 3 \\ &= (n_1 + n_2 + 1)(n_1 + n_2 + 3) \\ &= N(N+2). \end{aligned} \tag{B5.3}$$

Thus, we derive (5.15) from (B5.2) and (B5.3).

Substituting (5.15) into (5.4) and some manipulations yield

$$
\begin{aligned}
Q_i^C = n_i q_i^C &= \frac{n_i}{N}\left[a + (n_j + 1)\frac{n_j + 1 - n_i}{n_i(N+2)}a - n_j\frac{n_i + 1 - n_j}{n_j(N+2)}a\right] \\
&= \frac{n_i}{n_i N(N+2)}\left[n_i(N+2) + (n_j+1)(n_j + 1 - n_i) - n_i(n_i + 1 - n_j)\right]a \\
&= \frac{1}{N(N+2)}\left[n_i(N+2) + (n_j+1)^2 - n_i(N+1) + n_i n_j\right]a \\
&= \frac{(n_j+1)N}{N(N+2)}a = \frac{n_j+1}{N+2}a. \qquad \text{(B5.4)}
\end{aligned}
$$

Substituting (5.15) into (5.4) and rearranging terms, we obtain

$$
\begin{aligned}
Q^C &= \frac{1}{N}\left[(N-1)a + n_i\frac{n_j + 1 - n_i}{n_i(N+2)}a + n_j\frac{n_i + 1 - n_j}{n_j(N+2)}a\right] \\
&= \frac{1}{N(N+2)}\left[(N-1)(N+2) + (n_j + 1 - n_i) + (n_i + 1 - n_j)\right]a \\
&= \frac{N+1}{N+2}a. \qquad \text{(B5.5)}
\end{aligned}
$$

We substitute (B5.4) and (B5.5) into (5.10), so that we have

$$
W_i^C = (a - Q^C)Q_i^C = \frac{n_j+1}{(N+2)^2}a.
$$

C Derivation of s_i^L, s_j^F, W_i^L, and W_j^F

Substituting $s_j = r_j(s_i)$ into (5.4) and (5.5) yields

$$
\begin{aligned}
q_i(s_i, r_j(s_i)) &= \frac{1}{N}\left[a + (n_j+1)s_i - n_j\frac{n_i + 1 - n_j}{2n_j(n_i+1)}(a - n_i s_i)\right] \\
&= \frac{1}{2(n_i+1)N}\left[2(n_i+1)(a + (n_j+1)s_i) - (n_i + 1 - n_j)(a - n_i s_i)\right] \\
&= \frac{1}{2(n_i+1)N}\left[Na + (n_i^2 + n_i n_j + n_i + 2n_i + 2n_j + 2)s_i\right] \\
&= \frac{a + (n_i+2)s_i}{2(n_i+1)}, \qquad \text{(C5.1)}
\end{aligned}
$$

and

$$
\begin{aligned}
Q(s_i, r_j(s_i)) =& \frac{1}{N}\left[(N-1)a + n_i s_i + n_j \frac{n_i + 1 - n_j}{2n_j(n_i+1)}(a - n_i s_i)\right] \\
=& \frac{1}{2(n_i+1)N}\left\{[2(n_i+1)(N-1) + (n_i + 1 - n_j)]a\right\} \\
& \qquad + \frac{1}{2(n_i+1)N}\left\{n_i[2(n_i+1) - (n_i + 1 - n_j)]s_i\right\} \\
=& \frac{1}{2(n_i+1)N}\{[2(n_i+1)N - N]a + n_i N s_i\} \\
=& \frac{(2n_i+1)a + n_i s_i}{2(n_i+1)}.
\end{aligned} \tag{C5.2}
$$

We can rewrite (5.19) as

$$
(p(Q) - c)\left(\frac{\partial Q_i}{\partial s_i} + \frac{\partial Q_i}{\partial s_j} r_j'(s_i)\right) + p'(Q)Q_i\left(\frac{\partial Q}{\partial s_i} + \frac{\partial Q}{\partial s_j} r_j'(s_i)\right) = 0. \tag{C5.3}
$$

From (C5.1) and (C5.2), we get

$$
\frac{\partial Q_i}{\partial s_i} + \frac{\partial Q_i}{\partial s_j} r_j'(s_i) = n_i\left[\frac{\partial q_i}{\partial s_i} + \frac{\partial q_i}{\partial s_j} r_j'(s_i)\right] = \frac{n_i(n_i+2)}{2(n_i+1)}, \tag{C5.4}
$$

$$
\frac{\partial Q}{\partial s_i} + \frac{\partial Q}{\partial s_j} r_j'(s_i) = \frac{n_i}{2(n_i+1)}. \tag{C5.5}
$$

Substituting (C5.1), (C5.2), (C5.4), and (C5.5) into (C5.3) and rearranging terms yield

$$
\begin{aligned}
&(a - Q(s_i, r_j(s_i)))(n_i + 2) + Q_i(s_i, r_j(s_i)) = 0 \\
&\left[a - \frac{(2n_i+1)a + n_i s_i}{2(n_i+1)}\right](n_i+2) - n_i \frac{a + (n_i+2)s_i}{2(n_i+1)} = 0 \\
&(a - n_i s_i)(n_i+2) - n_i a - n_i(n_i+2)s_i = 0 \\
&a - n_i(n_i+2)s_i = 0.
\end{aligned}
$$

We easily derive (5.20) from the above equation. Substituting (5.20) into $s_j = r_j(s_i)$, we can easily obtain (5.21).

Substituting (5.20) into (C5.1) and (C5.2), we have equilibrium individual output and equilibrium total output as follows:

$$
q_i^L = q_i(s_i^L, r_j(s_i^L)) = \frac{1}{2n_i}a, \tag{C5.6}
$$

$$Q(s_i^L, r_j(s_i^L)) = \frac{2n_i + 3}{2(n_i + 2)} a. \tag{C5.7}$$

We also derive Q_j^F from (C5.6) and (C5.7), that is

$$Q_j^F = Q(s_i^L, r_j(s_i^L)) - n_i q_i^L = \frac{n_i + 1}{2(n_i + 2)} a. \tag{C5.8}$$

Therefore, we obtain the equilibrium level of welfare of each firm from (5.10) and (C5.6), (C5.7), and (C5.8):

$$\begin{aligned}
W_i^L &= [a - Q(s_i^L, r_j(s_i^L))]Q_i^L = \left[a - \frac{2n_i + 3}{2(n_i + 2)} a\right] \frac{1}{2} a \\
&= \frac{1}{4(n_i + 2)} a^2, \\
W_j^F &= [a - Q(s_i^L, r_j(s_i^L))]Q_j^F = \left[a - \frac{2n_i + 3}{2(n_i + 2)} a\right] \frac{n_i + 1}{2(n_i + 2)} a \\
&= \frac{n_i + 1}{4(n_i + 2)^2} a^2.
\end{aligned}$$

D Proof of Lemma 5.4

Comparing W_i^C with W_i^F from (5.16) and (5.23) yields

$$\begin{aligned}
W_i^C - W_i^F = {\frac{n_j + 1}{(N + 2)}}^2 a^2 - \frac{n_i + 1}{4(n_i + 2)^2} a^2 \geq (<) 0. \\
\Leftrightarrow N + 2 \leq (>) 2n_i + 4 \\
\Leftrightarrow n_i \leq (>) n_j + 1.
\end{aligned} \tag{D5.1}$$

Comparing W_i^L with W_i^C from (5.22) with (5.16) also yields

$$\begin{aligned}
W_i^L - W_i^C &= \frac{1}{4(n_i + 2)} a^2 - {\frac{n_j + 1}{(N + 2)}}^2 a^2 \\
&= \frac{a^2}{4(n_j + 2)(N + 2)} [(N + 2)^2 - 4(n_i + 1)(n_j + 2)] \\
&\propto [(n_i + 1) + (n_j + 2)]^2 - 4(n_i + 1)(n_j + 2) \\
&= [(n_i + 1) - (n_j + 2)]^2 = [n_i - (n_j + 1)]^2 \geq 0.
\end{aligned} \tag{D5.2}$$

From (D5.1) and (D5.2), we derive the best response of country i's government as follows. (1) Strategy L is its best response when $n_i \leq n_j$; (2) Both of them are its best response when $n_i = n_j + 1$; (3) Its best response is the strategy that is different from what the rival government chooses when $n_i \geq n_j + 2$. Therefore, we can obtain Lemma 5.4.

E Proof of Proposition 5.1

Subtracting (5.15) from (5.20) yields

$$\begin{aligned} s_i^L - s_i^C &= \frac{1}{n_i(n_i+2)}a - \frac{n_j + 1 - n_i}{n_i(N+2)}a \\ &\propto (n_i + n_j + 3) - (n_i + 2)(n_j + 1 - n_i) \\ &= (n_i + 1)(n_i + 1 - n_j). \end{aligned} \tag{E5.1}$$

From (E5.1), we can easily obtain the result that $s_i^L \geq (<) s_i^C$ when $n_j \leq (>) n_i + 1$.

Subtracting (5.21) from (5.15) yields

$$\begin{aligned} s_j^C - s_j^F &= \frac{n_i + 1 - n_j}{n_j(N+2)} - \frac{n_i + 1 - n_j}{n_i(n_i+2)}a \\ &\propto (n_i + 1 - n_j) f(n_j) \end{aligned} \tag{E5.2}$$

where

$$f(n_j) = -n_j^2 - (n_i + 3)n_j + 2n_i(n_i + 2).$$

We can easily show that $f(n_i) = n_i > 0, f(n_i + 1) = -2(n_i + 2) < 0$, and $f'(n_j) < 0$ for $n_j \geq 1$. From (E5.2), therefore, $s_j^C \geq s_j^F$.

F Proof of Proposition 5.3

When $n_j = n_i = n$ for $(i, j) = (1, 2)$, comparing (5.30) with (5.16) yields

$$\begin{aligned} W_i^{FT} - W_i^C &= \frac{n}{(2n+1)^2}a^2 - \frac{(n+1)}{(2n+3)^2}a^2 \\ &= \frac{(4n^2 + n - 1)a^2}{(2n+1)^2(2n+3)^2}a^2 > 0. \end{aligned} \tag{F5.1}$$

When $n_j \geq n_i + 1$, comparing (5.30) with (5.22) yields

$$\begin{aligned} W_i^{FT} - W_i^L &= \frac{n_i}{N^2}a^2 - \frac{1}{4(n_i+2)}a^2 \\ &= \frac{1}{4N^2(n_i+2)}[4n_i(n_i+2) - (n_i+n_j+1)^2]a^2 \\ &\propto -N^2(n_i+2) < 0. \end{aligned} \tag{F5.2}$$

From (F5.1) and (F5.2), we prove the statement (1) in Proposition 5.3.

Next, we will prove the statement (2). When $n_j \geq n_i + 1$, comparing (5.30) with (5.23) for country j yields

$$\begin{aligned} W_j^{FT} - W_j^F &= \frac{n_j}{N^2}a^2 - \frac{n_i+1}{4(n_i+2)^2}a^2 \\ &\propto 4(n_i+2)^2 n_j - (n_i+1)(n_i+n_j+1)^2. \end{aligned} \tag{F5.3}$$

Note that when $n_j = n_i + 1$ and $n_j = n_i + 2$, the RHS of (F5.3) is positive because

$$4(n_i+2)^2 n_j - (n_i+1)(n_i+n_j+1)^2 = 4(n_i+1)(2n_i+3) > 0,$$
$$4(n_i+2)^2 n_j - (n_i+1)(n_i+n_j+1)^2 = 8n_i^2 + 27n_i + 23 > 0.$$

We can translate the RHS of (F5.3) as a quadratic function of n_j:

$$\begin{aligned} &4(n_i+2)^2 n_j - (n_i+1)(n_i+n_j+1)^2 = \\ &= 4(n_i+2)^2 n_j - (n_i+1)[(n_i+1)^2 + 2(n_i+1)n_j + n_j^2] \\ &= -(n_i+1)n_j^2 + 2(n_i^2+6n_i+7)n_j - (n_i+1)^3 \equiv h(n_j). \end{aligned} \tag{F5.4}$$

Since $h(n_i + 2) > 0$, there is a unique critical value $\rho(n_i)$ such that $h(\rho(n_i)) = 0$ in the interval $[n_i + 2, \infty)$. From (F5.3) and (F5.4), therefore, we have proved the statement (2).

Finally, we will prove the statement (3). When $n_j = n_i = n$ for $(i, j) = (1, 2)$, we compare (5.32) with (5.31). Clearly, we obtain $W_3^{FT} < W_3^C$. When $n_j \geq n_i + 1$, we compare (5.33) with (5.31):

$$\begin{aligned} W_3^{FT} - W_3^{LF} &\propto 2(N-1)(n_i+2) - (2n_i+3)N \\ &= N - 2n_i - 4 = n_j - (n_i+3). \end{aligned} \tag{F5.5}$$

Thus, we have proved the statement (3) from (F5.5).

G Proof of Proposition 5.4

When $n_j = n_i = n$, we compare (5.36) with (5.35). Clearly, we obtain $W^{FT} < W^C$. When $n_j \geq n_i + 1$, we compare (5.37) with (5.35):

$$
\begin{aligned}
W^{FT} - W^{LF} \propto & (N^2 - 1)(2(n_i + 2))^2 - [(2(n_i + 2))^2 - 1]N^2 \\
= & N^2 - (2(n_i + 2))^2 \\
\propto & N - 2(n_i + 2) = n_j - (n_i + 3).
\end{aligned}
$$

Thus, we have proved the Proposition 5.4.

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Chapter 6
Endogenous Timing Decision on Trade Policies Between Importing and Exporting Countries with Many Firms

Yordying Supasri and Makoto Tawada

Abstract This chapter examines strategic trade policy games where the number of firms in the importing and exporting countries differs and each firm plays as a Cournot oligopolist. Under the assumption of linear demand and constant marginal cost, we show that, if the number of firms in the exporting country exceeds that of the importing country by more than three, the government of the exporting country chooses to behave as a leader and imposes an export tax on home firms. The government of the importing country becomes a follower and imposes an import tariff on foreign firms. The result is opposite to that of the previous study, where each country has only one firm.

Keywords Policy timing game • Two-country model • Arbitrary number of firms • Tariff and subsidy

6.1 Introduction

One of the most important issues in the analysis of strategic trade policies is how an importing country should cope with an export subsidy by an exporting country and how an exporting country should cope with an import tax by an importing country. To address this issue, it is important to investigate the timing decision of trade policies between two countries. For instance, Collie (1994) investigated the possibility of an importing country's countervailing duty where the endogenous timing decision on trade policies is taken into consideration as a part of the trade policy game. He showed in a simple two-country trade model that the timing of

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*,
New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_6

the policy decision becomes sequential, where the importing country government moves first to introduce an import tariff and the exporting country government moves second to introduce an export subsidy. As a result, countervailing duties do not appear in the importing country.

Collie (1994) illustrated this interesting result under the assumptions that there is only one firm in each country; all firms' marginal costs are constant; the market is located in only the importing country, and its demand is linear. However, the result may be quite different if we relax some of these assumptions. In fact, Ohkawa et al. (2002) examined the endogenous timing decision on policies under a three-country model of the Brander and Spencer type (1985), assuming that the number of firms in each exporting country is arbitrary. They found that the timing decision of trade policies is heavily dependent on the number of firms in each country.

Therefore, in the present chapter, employing the two-country model used by Collie (1994) but allowing an arbitrary number of firms in each country, we examine the timing decision of trade policies between two countries. Toshimitsu (2000) studied the same issue in a simple extended model of Collie's where the constant marginal costs are identical in each country but differ between countries. To understand how the number of firms in each country affects the timing decision, however, we simplify the model by assuming that the marginal cost is identical even between two countries.

The main results of this chapter are as follows: The importing country government moves first and the exporting country government moves second if and only if the number of firms in the exporting country is equal to or less than that of the importing country. As the number of firms in the exporting country becomes larger than that of the importing country, it becomes more likely that the exporting country government moves first and the other country government moves second. This is exactly so if the difference in the number of the firms is more than three. It is also shown in this case that the exporting country government uses an export tax rather than a subsidy. Hence, the subsidy is no longer a coherent policy choice for the exporting country. Moreover, in the case where the number of firms in the exporting country exceeds that of the importing country by just two, both governments move simultaneously.

The remainder of this chapter is organized as follows: In Sect. 6.2 the main model is presented. Our analysis is explored in Sects. 6.3, 6.4, 6.5, and 6.6. An interpretation of the results is given in Sect. 6.7. Section 6.8 is devoted to the conclusion.

6.2 Main Model

We consider an economy where two countries and one tradable commodity exist. One country is called an exporting country, and the other an importing country. Trade between the two countries occurs such that the exporting country exports the commodity to the other country. Each country has an arbitrary number of firms.

Consumption takes place only in the importing country, such that the whole amount of the commodity produced in the exporting country is exported to the importing country.

The demand for the commodity in the importing country market is represented by the linear demand function $Q = A - p$, where Q is the demand for the commodity, p is the commodity price, and A is a positive parameter expressing the market size. Thus, the inverse demand function of this market is $p = A - Q \equiv P(Q)$. Let n and m be the numbers of the firms in the importing and exporting countries, respectively. The cost function $C(x) = cx$ is identical for all firms, where x is a firm level output and c is a constant marginal cost. The market of the importing country is assumed to be sufficiently large to satisfy $A > c$.

All firms compete in a Cournot fashion in the market. Prior to competition among firms, the governments of the importing and exporting countries intervene in the market by imposing a tariff t per unit on the imports and giving a subsidy s^* per unit for the exports, respectively. The purpose of each government's intervention is to maximize its own national welfare. Finally, we assume that each government not only sets the level of an import tariff or an export subsidy but also decides the timing of the policy intervention.

Therefore, our present model is a three-stage game. In the first stage, the governments decide the timing of the policy intervention. In the second stage, given the timing of the policy decision in the first stage, the government of the importing country chooses the level of an import tariff to maximize its national welfare, while the government of the exporting country chooses the level of an export subsidy to maximize its national welfare. In the third stage, given the level of the import tariff and export subsidy determined in the second stage, each firm undertakes Cournot competition in the importing country's market and sets the level of output. The subgame-perfect Nash equilibrium is introduced as a solution for this three-stage game.

6.3 Analysis of the Third Stage

We now solve the three-stage game introduced in the previous section with backward induction. All firms located in the same country have an identical cost function and face the common government intervention. Therefore, the firm output level is the same for all firms within a country. Let q and q^* be the common output level of each firm in the importing and exporting countries, respectively. Considering this, we determine the behavior of the representative firm of the importing country to solve the third stage of the game.

The profit of the representative firm is expressed as

$$\pi = (a - (q + (n-1)\bar{q} + mq^*))q, \tag{6.1}$$

where $a \equiv A - c > 0$, $\bar{q}$ is the output of other firms in the importing country. Maximizing (6.1) with respect to q and bearing $\bar{q} = q$ in mind, we obtain the profit maximizing output under a given output level of the exporting country firms as

$$q = \frac{a - mq^*}{n+1}, \tag{6.2}$$

which is actually the reaction function of a firm in the importing country. Similarly, the representative firm's profit in the exporting country is expressed as

$$\pi^* = (a - (nq + q^* + (m-1)\bar{q}^*) - t + s^*)q^*, \tag{6.3}$$

where $\bar{q}^*$is the output of other firms in the exporting country. Maximizing (6.3) with respect to q^* and bearing $\bar{q}^* = q^*$ in mind, we obtain the profit maximizing output under a given output level of the importing country firms as

$$q^* = \frac{a - nq - t + s^*}{m+1}, \tag{6.4}$$

which is the reaction function of a firm in the exporting country.

Solving (6.2) and (6.4), we obtain the Cournot equilibrium output of each firm in the importing country and the exporting country as

$$q = \frac{a + m(t - s*)}{n+m+1} \equiv q(t - s^*), \tag{6.5}$$

and

$$q^* = \frac{a - (n+1)(t - s^*)}{n+m+1} \equiv q^*(s^* - t), \tag{6.6}$$

respectively. Therefore, the total output in equilibrium is given as

$$Q = \frac{(n+m)a - m(t - s^*)}{n+m+1} \equiv Q(t - s^*). \tag{6.7}$$

6.4 Analysis of the Second Stage

The next step is to examine the second stage of the game. In the second stage, under the given level of an export subsidy set by the exporting country government, the importing country government selects the level of an import tariff to maximize its national welfare. Likewise, under the given level of an import tariff set by the importing country government, the exporting country government chooses the level of an export subsidy so as to maximize its national welfare. The welfare of the importing country is defined as the sum of the consumer surplus, the profits of all firms, and the government's net revenue. Since there is no consumption in the exporting country, the welfare of the exporting country consists of the sum of the profits of all firms and the government's net revenue.

The consumer surplus of the importing country can be derived as $(A-p)^2/2$ by the demand function. Hence, the national welfare level of the importing country can be written as

$$W = W(t, s^*) = \frac{(A-p)^2}{2} + n\pi + mtq^*$$
$$= \frac{Q^2}{2} + (a-Q)nq + mtq^*, \tag{6.8}$$

By the use of (6.1), the national welfare of the exporting country can be written as

$$W^* = W^*(s^*, t) = m(\pi^* - s^*q^*)$$
$$= m(a-t-Q)q^*, \tag{6.9}$$

by the use of (6.2).

To derive optimal t, which maximizes W under a given level of s^*, we substitute (6.5), (6.6), and (6.7) into (6.8) and then maximize (6.8) with respect to t. Then, we have the optimal t as

$$t = \frac{(2n+1)a}{2n(n+2)+(m+2)} + \frac{n(n-m+2)+1}{2n(n+2)+(m+2)}s^* \equiv r(s^*), \tag{6.10}$$

from the first-order condition of the welfare maximization. Equation (6.10) is the reaction function of the importing country government to an export subsidy introduced by the exporting country government.

Next, we consider the exporting country's welfare. To seek the optimal level of s^*, maximizing W^* under a given level of t, we substitute (6.6) and (6.7) into (6.9) and then maximize (6.9) with respect to s^*. As a result, the optimal s^* can be obtained as

$$s^* = \frac{(n-m+1)a}{2m(n+1)} + \frac{m-n-1}{2m}t \equiv r^*(t), \tag{6.11}$$

which is actually the reaction function of the exporting country government to an import tariff imposed by the importing country government.

6.5 Some Lemmas

Before inspecting the third stage of the game where the timing of the policy decision is endogenously determined, we need to observe the slopes of the government reaction functions and the shapes of the iso-welfare curves of both countries. For this purpose, we propose some lemmas to illustrate the reaction curves and iso-welfare curves.

Since both government reaction functions are linear as seen in (6.10) and (6.11), we concentrate our attention on the coefficients of s^* and t of the reaction functions to see their slopes. We then easily establish the following lemma on the slopes.

Lemma 6.1 *Concerning the slopes of the reaction functions of both countries, it is possible to classify them into the following five cases:*

Case 1: If $m \leq n$, then $r'(s^*) > 0$ and $r^{*\prime}(t) < 0$,
Case 2: If $m = n + 1$, then $r'(s^*) > 0$ and $r^{*\prime}(t) = 0$,
Case 3: If $m = n + 2$, then $r'(s^*) > 0$ and $r^{*\prime}(t) > 0$,
Case 4: If $m = n + 3$ and $n = 1$, then $r'(s^*) = 0$ and $r^{*\prime}(t) > 0$,
Case 5: If $m = n + 3$ and $n \geq 2$, or if $m \geq n + 4$, then $r'(s^*) < 0$ and $r^{*\prime}(t) > 0$,
where $r'(s^*) \equiv dr(s^*)/ds^*$ and $r^{*\prime}(t) \equiv dr^*(t)/dt$.

Our next task is to examine the iso-welfare curves. First, we observe the iso-welfare curve of the importing country, which is described as

$$\left.\frac{dt}{ds^*}\right|_{W=\bar{W}} = -\frac{\partial W}{\partial s^*} \bigg/ \frac{\partial W}{\partial t}. \tag{6.12}$$

We define the locus of $\partial W/\partial s^* = 0$ with respect to s^* and t as the function $t = u(s^*)$. Substituting (6.5), (6.6), and (6.7) into (6.8) and calculating $\partial W/\partial s^* = 0$ with the use of (6.8) yield

$$t = \frac{(n-m)a}{n(n-m+2)+1} - \frac{m(2n+1)}{n(n-m+2)+1} s^* \equiv u(s^*). \tag{6.13}$$

Therefore, $u(s^*)$ has a slope opposite to that of $r(s^*)$ in sign. In particular, $u(s^*)$ is vertical when $r(s^*)$ is horizontal. Owing to (6.8), (6.12), and (6.13) and Lemma 6.1, we can establish

Lemma 6.2 *The following (i), (ii), and (iii) hold:*

(i) *In Cases 1, 2, and 3 of Lemma 6.1, where* $r'(s^*) > 0$ *and* $u(s^*) \equiv du(s^*)/ds^* < 0$*, the slope of the iso-welfare curve of the importing country is positive if* $sgn(t - r(s^*)) = sgn(t - u(s^*))$*, and negative if* $sgn(t - r(s^*)) \neq sgn(t - u(s^*))$.
(ii) *In Case 5 of Lemma 6.1, where* $r'(s^*) < 0$ *and* $u(s^*) > 0$*, the slope of the iso-welfare curve of the importing country is negative if* $sgn(t - r(s^*)) = sgn(t - u(s^*))$*, and positive if* $sgn(t - r(s^*)) \neq sgn(t - u(s^*))$.

(iii) In case 4 of Lemma 6.1, where $r'(s^*)$is horizontal and $u(s^*)$ is vertical, the slope of the iso-welfare curve of the importing country is positive if $sgn(t - \alpha) = sgn(s^* - \beta)$, and negative if $sgn(t - \alpha) \neq sgn(s^* - \beta)$, where α is the constant term of $r'(s^*)$ in (10) and $\beta \equiv -(m-n)a/(m(2n+1))$.

Proof See Appendix B.

We also have

Lemma 6.3 *If $s^* > (<) - a/(n+1)^2$, the importing country welfare level along its reaction curve rises (falls) for an increase in s^*.*

Proof See Appendix C.

Using Lemmas 6.1, 6.2, and 6.3, we can illustrate the government reaction curve and the iso-welfare curve of the importing country as in Figs. 6.1, 6.2 and 6.3. Figure 6.1 is for Cases 1, 2, and 3 of Lemma 6.1, Fig. 6.2 is for Case 4 of Lemma 6.1, and Fig. 6.3 is for Case 5 of Lemma 6.1.

Equations (6.10) and (6.13) show that the curves $t = r(s^*)$ and $t = u(s^*)$ intersect at the point $A = (t, s^*) = (na/(n+1)^2, -a/(n+1)^2)$. The reaction curve $t = r(s^*)$ cuts the t-axis at $B = (t, s^*) = ((2n+1)a/\left[2n(n+1) + (m+1)\right], 0)$and cuts the s^*-axis at $t = r(s^*)$, point B in the figures. It also cuts the horizontal axis at $D = (t, s^*) = (0, -(2n+1)a/\left[n(n-m+2)+1\right])$. Thus, at B, $t > 0$ in any cases. However, at D, $s^* < 0$ if $m \leq n+2$, and $s^* > 0$ if $m = n+3$ and $n \geq 2$ or if $m \geq n+4$.

As for the curve $t = u(s^*)$, it cuts the t-axis at $E = (t, s^*) = ((n-m)a/[n(n-m+2)+1], 0)$. So, at E, $t \geq 0$ if $m \leq n$, and $t < 0$ if $n < m \leq n+2$. Moreover, if $m = n+3$ and $n \geq 2$ or if $m \geq n+4$, $t > 0$ at E. The curve $t = u(s^*)$ also cuts the s^*-axis at $F = (t, s^*) = (0, (n-m)a/m(2n+1))$. So it is obvious that $s^* >, =, < 0$ according to $n >, =, < m$ at F. These observations yield Figs. 6.1, 6.2, and 6.3.

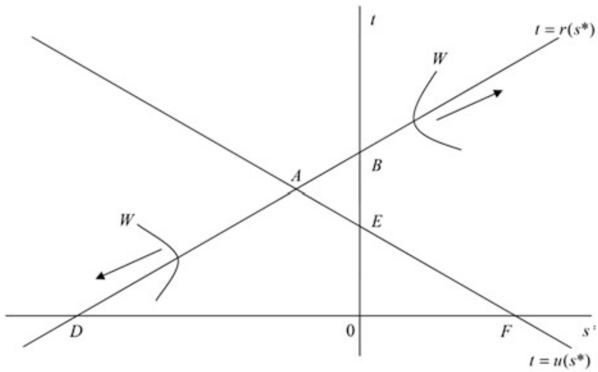

Fig. 6.1 Reaction curve and the iso-welfare curves of the importing country where $m \leq n+2$

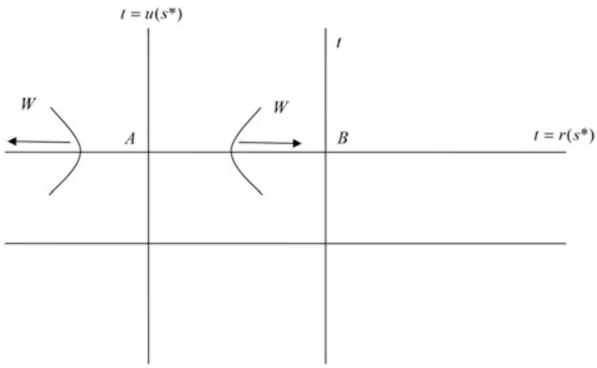

Fig. 6.2 Reaction curve and the iso-welfare curves of the importing country where $m = n + 3$ and $n = 1$

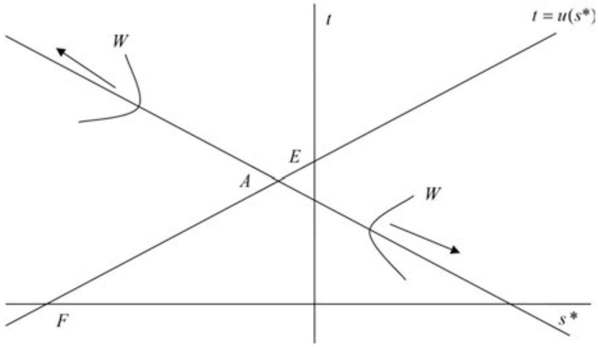

Fig. 6.3 Reaction curve and the iso-welfare curves of the importing country where $m = n + 3$ and $n \geq 2$ or where $m \geq n + 4$

The movement of the iso-welfare curve of the importing country, which is drawn as W in each figure, in the direction indicated by the arrows indicates a higher level of the national welfare, because of Lemma 6.3.

We turn our attention to the exporting country. The slope of the iso-welfare curve of the exporting country is

$$\left.\frac{ds^*}{dt}\right|_{W^*=\bar{W}^*} = -\frac{\partial W^*}{\partial t} \Big/ \frac{\partial W^*}{\partial s^*}. \tag{6.14}$$

We define $s^* = u^*(t)$ as the relation of $\partial W^*/\partial t = 0$ with respect to t and s^*. Substituting (6.6) and (6.7) into (6.9) and calculating $\partial W^*/\partial t = 0$ by the use of (6.9) yield

$$s^* = \frac{2a}{m-n-1} - \frac{2(n+1)}{m-n-1}t \equiv u^*(t). \tag{6.15}$$

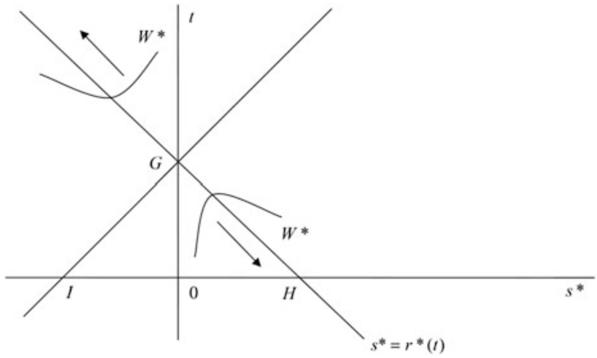

Fig. 6.4 Reaction curve and the iso-welfare curve of the exporting country where $m \leq n$

Because of (6.11) and (6.15), the slope of $u^*(t)$ is opposite to that of $r^*(t)$ in sign. In view of (6.9), (6.14), (6.15), and Lemma 6.1, we obtain

Lemma 6.4 *The following (i), (ii), and (iii) hold.*

(i) In Case 1 of Lemma 6.1, where $r^{*\prime}(t) < 0$ and $u^{*\prime}(t) > 0$, the slope of the iso-welfare curve of the exporting country is negative (positive) if $sgn(s^* - r^*(t)) = (\neq) sgn(s^* - u^*(t))$.

(ii) In Cases 3, 4, and 5 of Lemma 6.1, where $r^{*\prime}(t) > 0$ and $u^{*\prime}(t) < 0$, the slope of the iso-welfare curve of the exporting country is positive (negative) if $sgn(s^* - r^*(t)) = (\neq) sgn(s^* - u^*(t))$.

(iii) In Case 2 of Lemma 6.1, where $r^{*\prime}(t) = 0$ and $u^{*\prime}(t) = \infty$, the slope of the iso-welfare curve of the exporting country is positive (negative) if $sgn(t - \alpha^*) = (\neq) sgn(s^* - \beta^*)$, where $\alpha^* = a/(n+1)$ and $\beta^* = 0$.

Proof The proof is given in Appendix D.

Furthermore, we obtain:

Lemma 6.5 *Suppose $t > (<) a/(n+1)$; then the welfare level of the exporting country moves up (down) along its government reaction curve as t increases.*

Proof Given that this lemma can be proved in a similar manner to that of Lemma 6.3, we omit the proof.

Using Lemmas 6.1, 6.4, and 6.5, we can depict the government reaction curves and iso-welfare curves of the exporting country as in Figs. 6.4, 6.5, and 6.6.

Figures 6.4 is for Case 1 of Lemma 6.1, Fig. 6.5 is for Case 2 of Lemma 6.1, and Fig. 6.6 is for Cases 3, 4, and 5 of Lemma 6.1. In these figures, G exhibits the point where the two curves $s^* = r^*(t)$ and $s^* = u^*(t)$ intersect; thus, $(t, s^*) = (a/(n+1), 0)$ at G. The reaction curve $s^* = r^*(t)$ cuts the s^*-axis at $s^* = (n - m + 1)a/2m(n+1)$. This point is signified as H in the figures. Concerning point H, $s^* > 0$ if $m \leq n$ and $s^* < 0$ if $m \geq n+2$. As for the curve $s^* = u^*(t)$, it cuts the

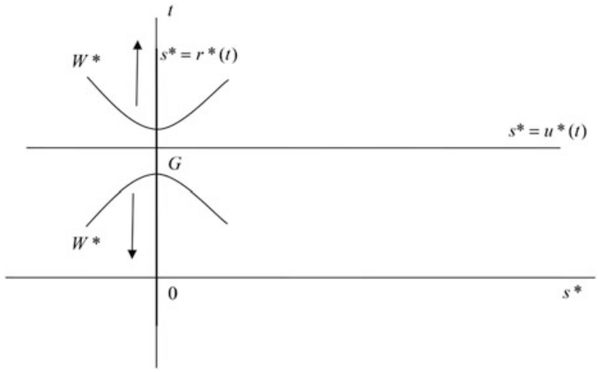

Fig. 6.5 Reaction curve and the iso-welfare curve of the exporting country where $m = n + 1$

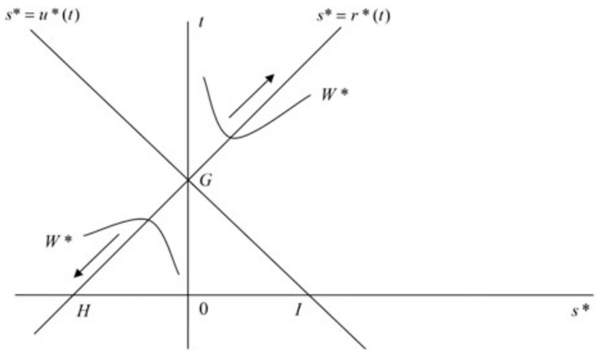

Fig. 6.6 Reaction curve and the iso-welfare curve of the exporting country where

s^*-axis at $s^* = 2a/(m - n - 1)$. This point is signified as I in the figures. Hence, at point I, $s^* < 0$ if $m \leq n$ and $s^* > 0$ if $m \geq n + 2$.

In these figures, the iso-welfare curves can be drawn as W^* owing to Lemma 6.4. When these curves move to the direction indicated by arrows, the national welfare level of the exporting country goes up in view of Lemma 6.5.

6.6 Analysis of the First Stage

Combining the figures of the government reaction curves of both countries, we can see the timing of the two countries' trade policy decisions. We will analyze each case of Lemma 6.1 independently.

Case 1. $m \leq n$ where $r'(s^*) > 0$ and $r^{*\prime}(t) < 0$.

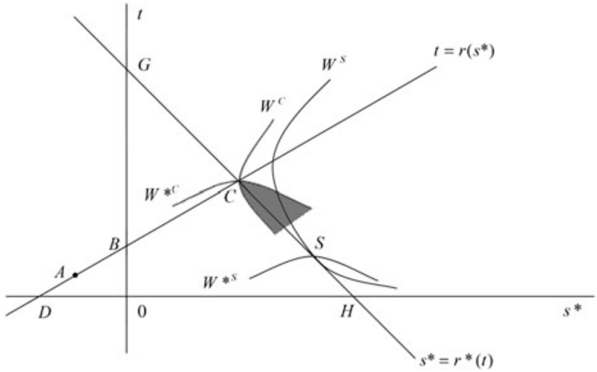

Fig. 6.7 Equilibrium of the policy game where $m \leq n$

In this case, Figs. 6.1 and 6.4 yield Fig. 6.7. In this figure, the shaded area expresses the Pareto superior region to the Cournot-Nash equilibrium point C, where the two reaction functions intersect. Point G is located in the first quadrant because $t = (2n+1)a/[2n(n+1)+(m+1)]$ of B is lower than $t = a/(n+1)$ of G. The exporting country's reaction curve passes through the Pareto superior area, as seen in the figure. Therefore, applying Hamilton and Slutsky's theorem, the timing decisions of the two governments are sequential, such that the importing country government moves first as a leader and the other moves second as a follower. As a result, the government policy game becomes a Stackelberg type, and the equilibrium is indicated by point S in Fig. 6.7.

Let us calculate t and s^* at S. Because the importing country government acts as a leader, it maximizes $W = W(t, s^*(t))$ with respect to t. We then obtain

$$t = \frac{(2n+1)a}{(2n+3)(n+1)} > 0 \tag{6.16}$$

and

$$s^* = \frac{(n-m+1)a}{m(2n+3)(n+1)} > 0. \tag{6.17}$$

at the equilibrium S, which is in the first quadrant of Fig. 6.7. This implies that the importing country government uses an import tariff, while the exporting country government adopts an export subsidy.

Case 2. $m = n + 1$ where $r'(s^*) > 0$ and $r^{*\prime}(t) = 0$.

In this case, Fig. 6.8 is derived from Figs. 6.1 and 6.6. Whatever policy the importing country government chooses, the exporting country government does not execute any trade policy. This implies that the exporting country government is not concerned about the timing of the trade policy decision. In the figure, the equilibrium

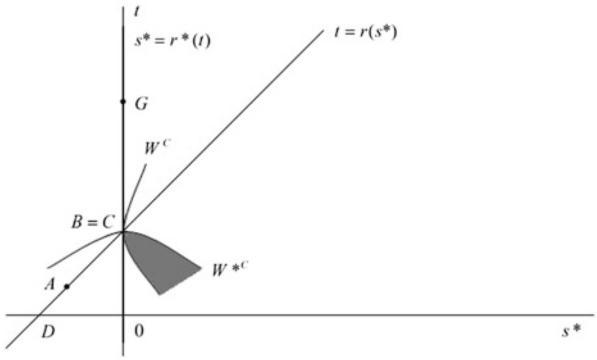

Fig. 6.8 Equilibrium of the policy game where $m = n + 1$

point appears as point B(=C) such that $t = (2n + 1)a/(2n + 3)(n + 1) > 0$ and $s^* = 0$. Thus, the importing country government imposes an import tariff on imports, while the other government does nothing.

Case 3. $m = n + 2$ where $r'(s^*) > 0$ and $r^{*\prime}(t) > 0$.

In this case, Fig. 6.2 combined together with Fig. 6.5 yields Fig. 6.7. In the figure, G is located above B. We can observe that D takes a position in the left-hand side of H along the s^*-axis. This is because $s^* = -(2n + 1)a/\,[n(n - m + 2) + 1]$ at D is smaller than $s^* = (n - m + 1)a/2m(n + 1)$ at H. Hence, two reaction curves intersect in the second quadrant. The point is exhibited as C, where

$$t = \frac{(2n^2 + 4n + 1)a}{(2n^2 + 6n + 5)(n + 1)} > 0, \tag{6.18}$$

and

$$s^* = -\frac{a}{(2n^2 + 6n + 5)(n + 1)} < 0, \tag{6.19}$$

in view of (6.10) and (6.11).

To seek the Pareto superior region to C, we draw the iso-welfare curves of both countries at C. As already shown, G is the point where the exporting country's welfare is the lowest along its reaction curve, while A is the corresponding point for the importing country. In fact, A should be located below C along the importing country's reaction curve. This is because $s^* = -a/(n + 1)^2 < 0$ at A is smaller than that of C. In Fig. 6.9, W and W^* are, respectively, the iso-welfare curves of the importing and exporting countries passing through C. The shaded area is Pareto superior to C. According to Hamilton and Slutsky's theorem, both countries move first, so that the equilibrium point becomes C. Thus, equilibrium t and s^* are those (6.18) and (6.19), respectively. The importing country and exporting country governments use an import tariff and an export tax, respectively, in this case.

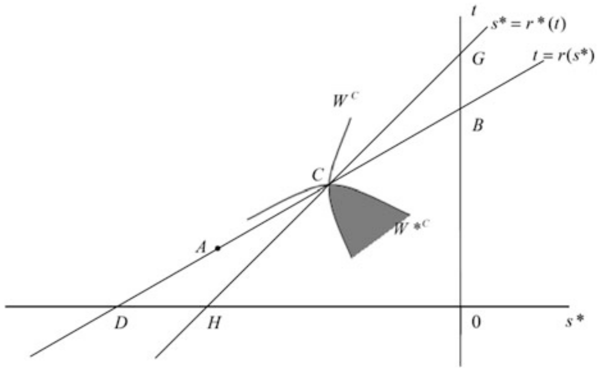

Fig. 6.9 Equilibrium of the policy game where $m = n + 2$

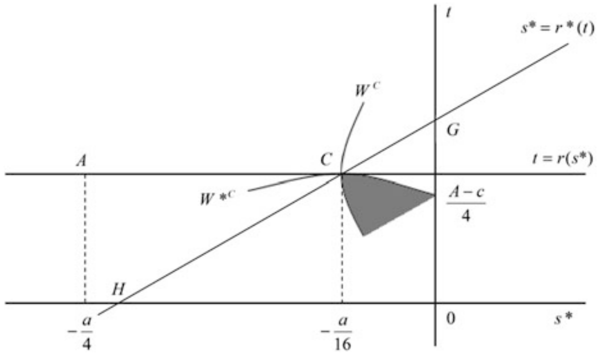

Fig. 6.10 Equilibrium of the policy game where $m = n + 3$ and $n = 1$

Case 4. $m = n + 3$ and $n = 1$ where $r'(s^*) = 0$ and $r^{*\prime}(t) > 0$.

Since $n = 1$ and $m = 4$ in this case, the government reaction functions reduce to $t = r(s^*) = a/4$ and $s^* = r^*(t) = -a/8 + t/4$, from which we have Fig. 6.10.

In the figure, two reaction curves intersect with each other at C, where $t = a/4 > 0$ and $s^* = -a/16 < 0$. The shaded area represents the Pareto superior region to C.

Figure 6.10 enables us to apply a similar argument to Case 2 and to conclude that the exporting country government moves first with an export tax and the other government is indifferent to the timing of the decision but uses an import tariff.

Case 5. $m = n + 3$ and $n \geq 2$, or $m \geq n + 4$, where $r'(s^*) < 0$ and $r^{*\prime}(t) > 0$.

Figures 6.2 and 6.5 assure Fig. 6.11 in this case.

The government reaction curve of the importing country passes through in the shaded Pareto superior region to the Cournot point C. Then, in a manner similar to Case 1, we can conclude that the exporting country government moves first and the other moves second in policy timing. Accordingly, we have a Stackelberg equilibrium indicated by S in the figure.

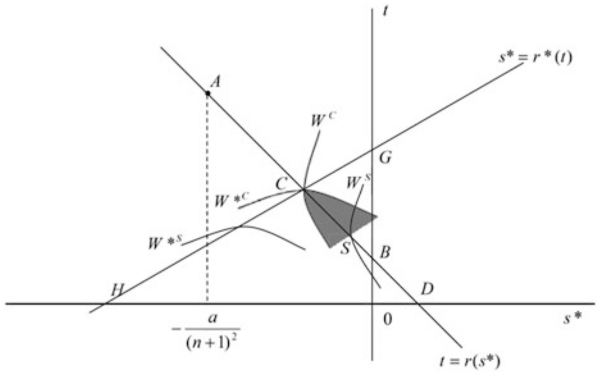

Fig. 6.11 Equilibrium of the policy game where $m = n + 3$ and $n \geq 2$, or $m \geq n + 4$

The equilibrium values of t and s^* are, respectively,

$$t = \frac{\left[(n+1)^2(2n+1) + nm\right] a}{2(n+1)^2\left[n(n+2) + m + 1\right]}, \tag{6.20}$$

and

$$s^* = -\frac{ma}{2(n+1)^2\left[n(n+2) + m + 1\right]}, \tag{6.21}$$

implying that the importing country government imposes an import tariff, while the other imposes an export tax.

We are now in a position to summarize all of these results as the following proposition:

Proposition 6.1 *Suppose that the market demand is linear and all firms have an identical constant marginal cost. Then, depending on how different the number of the firms between countries is, the timing of policy decision and the type of trade policy adopted in each country are as follows:*

1. *If the number of firms in the importing country is equal to or greater than that of the other country, the timing of the policy decision is sequential, such that the importing country government moves first and the exporting country government moves second. The former government imposes an import tariff, and the latter government uses an export subsidy.*
2. *If the number of firms in the exporting country is larger than that of the importing country by just one, the timing of policy intervention is such that the importing country government moves first and the exporting country is indifferent to the timing decision. The former government imposes an import tariff, and the latter government never intervenes in trade.*
3. *If the number of firms in the exporting country is larger than that of the importing country by just two, the timing of trade intervention is simultaneous, such that*

both governments move at once. The importing country government uses an import tariff, and the other adopts an export tax.

4. *If the number of firms in the exporting country is larger than that of the importing country by just three and if only one firm exists in the importing country, the timing of trade intervention is such that the importing country government is indifferent to the timing and so the other government moves first. The former government uses an import tariff, and the latter uses an export tax for intervention.*
5. *If the number of firms in the exporting country is larger than that of the importing country by just three and the number of firms in the importing country is more than one, or if the number of firms in the exporting country is larger than that of the importing country by at least four, then the timing of trade intervention is sequential, such that the importing government moves first and the other moves second. The former government uses an import tariff, and the other uses an export tax for trade intervention.*

Table 6.1 is for a summary of Proposition 6.1.

6.7 Interpretation of the Results

Here, we present an intuitive explanation of the above results. We focus only on the results (1) and (5) of Proposition 6.1, which are extremely opposite, since other cases are marginal cases between these two.

Consider first the case where the number of firms in the importing country is equal to or larger than that of the exporting country. Since the market shares of the firms in the importing and exporting countries are nq and mq^*, respectively, the gap between these market shares is

$$nq - mq^* = \frac{(n-m)a + m(2n+1)(t-s^*)}{n+m+1}, \tag{6.22}$$

by (6.5) and (6.6). Since $n \geq m$, it is clear from (6.16) and (6.17) that $t > s^*$. Therefore, we have $nq > mq^*$. As the market share of the exporting country firms is small, the exporting country government attempts to enlarge the market share by an export subsidy. In the importing country, consumption depends mainly on the products of the domestic firms rather than imports, and the importing country's welfare depends mainly on consumer surplus and the profits of the domestic firms. These two elements are in conflict with respect to the commodity price. If the commodity price goes up, the consumer surplus decreases, and the profits of domestic firms increase. In the case where the market share of the domestic firms is sufficiently large, however, the total profit accruing to the domestic firms is more influential on welfare than the consumer surplus. Thus, the importing country government prefers to use a tariff as its trade policy.

Table 6.1 Summary of the results where the numbers of firms in the importing and exporting countries are n and m

Number of firms	Timing decision	Policy adopted		Government situation	
		Importing country	Exporting country	Importing country	Exporting country
$m \leq n$	Sequential	Import tariff	Export subsidy	Leader	Follower
$m = n + 1$	Indecisive	Import tariff	Free trade	Leader	Leader or follower
$m = n + 2$	Simultaneous	Import tariff	Export tax	Leader	Leader
$m = n + 3$ and $n = 1$ ($n = 1$ and $m = 4$)	Indecisive	Import tariff	Export tax	Leader or follower	Leader
$m = n + 3$ and $n \geq 2$ or $m \geq n + 4$	Simultaneous	Import tariff	Export tax	Follower	Leader

To understand our result on the timing in this case, we should first notice by Fig. 6.7 that the importing (exporting) country welfare country goes up as an increase in the level of the tariff (subsidy) along its reaction curve at the Cournot point where two reaction curves intersect. Taking this into account, we can determine whether a country prefers to be a leader or a follower by the shape of its reaction curve. The exporting country government has a negatively sloping reaction curve, so that its strategy is useful to the importing country's welfare; namely, if the exporting country government wants to raise its welfare level along the reaction curve, the importing country welfare also goes up. However, since the reaction curves of the importing country are positively sloping, the strategy of the importing country government is in conflict with the exporting country's welfare. That is, if the importing country wants to raise its welfare level along the reaction curve, the exporting country's welfare necessarily falls. These facts determine the equilibrium of the timing game such that the exporting country government moves second, while the importing country government moves first.

Similarly, we can provide an intuitive explanation of our results in the case where the number of firms in the exporting country exceeds that of the importing country by more than three. In this case, we have $t - s^* > 0$ from (6.20) and (6.21). Then, by (6.22), we obtain $|(n-m)a| > |m(2n+1)(t-s^*)|$. Therefore, $nq < mq^*$. The market share of the exporting country firms is so large that consumption in the importing country depends much on imports rather than domestic products. This means that exports affect the commodity price more seriously than domestic products. Thus, to retain monopoly rents, the exporting country government prefers to use the export tariff to prevent the commodity price from falling. However, the importing country welfare depends substantially on the revenue from the import tariff, so that the importing country government is fond of using a tariff as a trade policy. According to Fig. 6.11, the importing (exporting) country welfare rises as a decrease in the tariff (subsidy) along its reaction function at the Cournot point where the two reaction curves intersect. This, together with the fact that the importing (exporting) country government has the reaction curve with a negative (positive) slope, reveals that the strategy of the importing (exporting) country government is favorable (unfavorable) to the other country's welfare. So, the exporting country government prefers to move first, and the other prefers to move second.

6.8 Concluding Remarks

Concerning the trade policies between exporting and importing countries, it is interesting to ask which case is the more plausible: the case where, as the exporting country government encourages exporting firms to export by giving an export subsidy, the importing country government imposes a countervailing duty on the imports to protect the domestic firms or the case where, as the importing country government tries to protect the domestic firms by imposing a tariff on imports, the exporting country government uses an export subsidy as a counter policy.

Collie (1994) investigated this problem and showed that the importing country government intervenes first in trade and the exporting country government reacts to it. Collie's analysis (1994) was, however, based on the assumption that there is only one firm in each trading country. Thus, we relaxed this assumption by allowing any number of firms to exist in each country and examined Collie's proposition. Then, we found that Collie's proposition holds only if the number of firms in the importing country is equal to or greater than that of the exporting country. If the number of firms in the exporting country exceeds that of the importing country by more than three, a result opposite to Collie's appears; that is, the exporting country government moves first and the other moves second in the trade intervention. We also showed that the exporting country government uses subsidy as a trade intervention only if the number of firms in the exporting country is not less than in the other country. In any other cases, the exporting country government prefers to use an export tax whenever the government intervenes in trade.

In the present chapter, we confined our analysis to the case where the marginal cost is identical among all firms in each country as well as between countries. This assumption is stronger than Collie's, where the marginal cost does not need to be identical between two countries. By this stronger assumption, we could reveal mechanically the essence of the relation of the timing of policy decisions with the difference in the number of firms between countries.

Acknowledgements We would like to express our gratitude to Professors Masayuki Hayashibara, Yasushi Kawabata, Murray C. Kemp, Jaerang Lee, Arnold Schweinberger, Koji Shimomura, and Tsuyoshi Toshimitsu for the original paper. We also thank the publisher John Wiley & Sons Ltd. for permitting us to reuse the original paper "Endogenous Timing in a Strategic Trade Policy Game: A Two-country Oligopoly Model with Multiple Firms," Review of International Economics. Vol.11, pp.275–290, 2007, for this chapter.

Appendix

A: Theorem 5 of Hamilton and Slutsky (1990)

(A) The case where both reaction functions have slopes of the same sign.

  (i) When neither reaction function intersects the Pareto superior set relative to the simultaneous move equilibrium, the unique equilibrium of the extended game is the simultaneous move equilibrium. Both players intend to move first (intend to be leader).

  (ii) When both reaction functions have slopes opposite in sign, one and only one reaction function enters the set of outcomes Pareto superior to the simultaneous move outcome, so the unique outcome in the extended game is that the player whose reaction function enters the Pareto superior set moves second (acts as follower), and the player whose reaction function does not enter the Pareto superior set moves first (acts as leader).

B: The proof of Lemma 6.2

Substituting (6.5), (6.6), and (6.7) into (6.8) and maximizing (6.8) with respect to t, we have

$$\frac{\partial W}{\partial t} = \varphi\{(2n+1)a+(n(n-m+2)+1)s^{*}-[(2n(n+2)+(m+2)]t\} = 0, \qquad \text{(B6.1)}$$

where $\varphi = m/(n+m+1)^2$. Equation (6.10) can be derived by rewriting (B6.1). Notice that $\partial W/\partial t = 0$ at $t = r(s^*)$. This, together with (B6.1), yields

$$\frac{\partial W}{\partial t} \gtreqless 0 \quad \text{as} \quad t \lesseqgtr r(s^*). \qquad \text{(B6.2)}$$

Similarly, we can derive

$$\frac{\partial W}{\partial s^*} = \varphi\{(m-n)a + m(2n+1)s^* + (n(n-m+2)+1)t\} = 0, \qquad \text{(B6.3)}$$

From which we have (6.13).

Suppose $m \leq n+2$, implying that the reaction function of the importing country has a positive slope. Then, $n(n-m+2)+1 > 0$, so that we derive

$$\frac{\partial W}{\partial s^*} \lesseqgtr 0 \quad \text{as} \quad t \lesseqgtr u(s^*), \qquad \text{(B6.4)}$$

by a similar way to derive (B6.2).

Next, suppose the case where $m = n+3$ and $n \geq 2$ or where $m \geq n+4$; then the reaction function of the importing country has a negative slope and $n(n-m+2)+1 < 0$. In this case, we have

$$\frac{\partial W}{\partial s^*} \gtreqless 0 \quad \text{as} \quad t \lesseqgtr u(s^*). \qquad \text{(B6.5)}$$

Making use of (6.12), we can examine the slope of the iso-welfare curve of the importing country. In the case where $m \leq n+2$, in view of (B6.2), (B6.4), and (6.12), the slope of the iso-welfare curve of the importing country is positive (negative) if $sgn(t - r(s^*)) = (\neq) sgn(t - u(s^*))$. In the case where $m = n+3$and $n \geq 2$ or where $m \geq n+4$, in view of (B6.2), (B6.5), and (6.11), the slope of the iso-welfare curve of the importing country is negative (positive) if $sgn(t - r(s^*)) = (\neq) sgn(t - u(s^*))$.

Similarly, in the case where $m = n+3$ and $n = 1$, we can show (iii) by (B6.2), and (B6.3) implies (iii).

C: The Proof of Lemma 6.3

The importing country's welfare in its government reaction curve $t = r(s^*)$ can be expressed as $W = W(r(s^*), s^*)$. To investigate how the welfare on the reaction curve changes by an increase in s^*, we differentiate $W = W(r(s^*), s^*)$ with respect to s^*. Then we have

$$\frac{dW(r(s^*), s^*)}{ds^*} = \frac{\partial W}{\partial t}\frac{dr}{ds^*} + \frac{\partial W}{\partial s^*} = \frac{\partial W}{\partial t}, \tag{C6.1}$$

because of $\partial W/\partial t = 0$ on the reaction curve.

According to (6.10) and (6.13), the two curves $t = r(s^*)$ and $t = u(s^*)$ intersect at the point where $t = na/(n+1)^2 > 0$ and $s^* = -a/(n+1)^2 < 0$. Suppose that $m \leq n+2$. Then it follows from (B6.4) that

$$\frac{\partial W}{\partial s^*} \underset{>}{\overset{<}{-}} 0 \text{ as } t \underset{>}{\overset{<}{-}} u(s^*). \tag{C6.2}$$

Therefore, we assert that:

$$\frac{\partial W}{\partial s^*} \underset{>}{\overset{<}{-}} 0 \text{ along the curve of } t = r(s^*) \text{ as } s^* \underset{>}{\overset{<}{-}} -\frac{a}{(n+1)^2}. \tag{C6.3}$$

This covers Cases 1, 2, and 3 of Lemma 6.1. In the other cases of Lemma 6.1, we can also show (C6.3) in a similar way.

D: The Proof of Lemma 6.4

Applying the same method to obtain (B6.1) and (B6.3), we have

$$\frac{\partial W^*}{\partial s^*} = \varphi\{(n-m+1)a + (n+1)(m-n-1)t - 2m(n+1)s^*\} = 0. \tag{D6.1}$$

and

$$\frac{\partial W^*}{\partial t} = (n+1)\varphi\{-2a + 2(n+1)t + (m-n-1)s^*\} = 0. \tag{D6.2}$$

By the use of these two equations and the same way used to prove Lemma 6.2, we can show the lemma.

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Part III
The Roles of Trade Policies

Chapter 7
Government Intervention Brings About Free-Trade Outcomes in the Long Run

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Abstract We examine the long-run effect of government intervention on economic outcomes in an importing country in a three-country framework with free entry of the importing country's firms. We establish the following. [1] The long-run equilibrium total output (or price) level under government intervention regime is the same as that under the free-trade regime. Without the imposition of a tariff, the importing country's welfare is unaffected by any level of export subsidy. [2] In the long-run equilibrium, each exporting country's government sets a positive subsidy level such that each exporter can attain the equilibrium outcome when it adopts marginal cost pricing.

Keywords Strategic trade policy • Long-run equilibrium • Strategic interaction • Marginal cost pricing

7.1 Introduction

Many researchers have dealt with various topics of strategic trade policy game in a three-country framework. Brander and Spencer (1985) (Eaton and Grossman, 1986) showed that optimal export subsidy level is positive when each exporter becomes a Cournot (Bertrand) duopolist in the importing country market. Krishna and Thursby (1991) extended Brander and Spencer's (1985) model by proposing that each exporting country has more than one firm and showed that whether exporting governments should use an export subsidy or tax depends on the relative magnitude

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*,
New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_7

of strategic distortion and terms of trade distortion. Hwang and Schulman (1993) introduced the stage where each government chooses either market intervention or free trade in Krishna and Thursby's (1991) model. They showed that two types of equilibria emerged: if the difference between the number of exporting firms is not less than 1, then quasi-free trade (unilateral intervention) occurs; otherwise, bilateral intervention occurs. In other words, unilateral intervention tends to emerge. These articles are short-run analyses in that the number of exporters is fixed; i.e., entry-exit behavior is not considered.

Schulman (1997) and Etro (2011) are exceptional articles in the three-country framework *with* entry-exit behavior. Schulman (1997) introduced the entry-exit behavior of each country's exporter into Hwang and Schulman's (1993) model and examined the equilibrium outcomes in the long run. They showed that bilateral intervention occurs in a certain range of both the difference in the number of firms between two exporting countries and the fixed entry cost. They also showed that free trade may occur in another range. These results are different from those in the short run.

Etro (2011) constructed a "*n* country" model with general demand and cost functions where one firm exists in each country. In this generalized model of the three-country framework, he examined unilateral intervention by export subsidy in the home country and concluded the following: the home government sets a positive rate of export subsidy under competition in quantity as well as price when the number of exporting firms is endogenously determined; it sets a positive (negative) rate under competition in quantity (price) when the number of firms is exogenously determined.[1]

Certainly these studies examined the long-run equilibrium by focusing on the endogeneity of the number of exporters, but they neither explicitly compared the short-run equilibrium outcome with that of the long-run nor provided the intuitive explanation of the long-run outcome. Hayashibara et al. (2007) partially showed the former comparison but did not address the latter's intuitive explanation. This chapter will add some new results to this comparison and try to explain the differences in the equilibria.

To this end, we consider the three-country framework with the entry of the third importing country's firms.[2] This framework is regarded as an extension of Brander and Spencer (1985) and Krishna and Thursby (1991). We construct the following three-stage game: In the first stage, each foreign exporting country government

[1]Strategic trade policy under free entry has also been analyzed in other frameworks. For example, Venables (1985) examined strategic subsidy and tax in the reciprocal dumping model under free entry and exit. Markusen and Venables (1988) compared the effects of trade policies in a segmented market with their effects in an integrated market. De Santis and Stähler (2001) examined optimal taxes and domestic production subsidies for exporting industries under free entry, assuming that domestic firms are not subject to competition by foreign firms in the domestic or foreign markets.

[2]In developing countries, the following phenomenon is often observed: domestic firms enter into their respective markets, where exporters solely belonging to developed countries supply a good, and then the domestic firms compete against the foreign exporters.

determines the level of export subsidy to its firms. In the second stage, given the level of export subsidy set by each exporting country government, each of the importing country's firms determines whether to enter the importing country's market. In the third stage, given the subsidy rates and the number of firms, all firms compete in Cournot fashion in the home country market.

We establish the following: (1) In the short-run equilibrium, strategic interaction of policy variables through price change occurs, whereas in the long-run equilibrium, strategic interaction vanishes; i.e., strategic independence prevails. (2) Owing to strategic independence, the optimal subsidy rate brings about marginal cost pricing in the long run. (3) Strategic independence brings about the irrelevance result: the equilibrium outcome does not depend at all on the timing of subsidy policy implementation or the difference between the numbers of the three countries' firms in the long run. (4) Strategic independence allows the equilibrium price under government intervention to equal that under free trade.

We will extend our model by introducing an import tariff. This extension adds to the first-stage subgame mentioned above the tariff policy implemented by the importing country's government. We establish the following result: (5) Even if a tariff is introduced into our model, the result shown in (4) holds.

The rest of the chapter is organized as follows: Sect. 7.2 presents the model. Section 7.3 analyzes the short-run equilibrium. Section 7.4 examines the long-run analysis. Section 7.5 shows the main results. Section 7.6 introduces the import tax to our model and shows some results. Section 7.7 concludes the chapter. Section 7.7 provides a mathematical appendix.

7.2 The Model

The model consists of two foreign exporting countries, named country 1 and country 2, and one home developing country named country 3. In this model, solely a homogeneous goods market exists. Our model can be considered as an extension of the *three-country* model of Krishna and Thursby (1991) in that it adds firms native to the importing country.

An inverse demand function of country 3's market is $p = p(Q)$ where p is the market price and Q is the total output. We impose the following assumption:

Assumption 7.1 $p'(Q) < 0$ *and* $p''(Q)Q + p'(Q) \leq 0$.[3]

There are n_i firms in country $i(= 1, 2, 3)$ with $n_1 \geq 1$, $n_2 \geq 0$ and $n_3 \geq 0$. A cost function of firm k in country i is $c_{ik} = c_i(q_{ik})$, $i = 1, 2, 3$, $k = 1, \ldots, n_i$ where q_{ik} is quantity supplied by firm k in the country i. We assume that

[3]This condition ensures that demand function is not too convex.

Assumption 7.2 *$c_i(q_{ik})$ is a convex function of q_{ik} satisfying $c_i(0) = 0$, $c_i'(q_{ik}) \geq 0$, and $c_i''(q_{ik}) > 0$ for any $q_{ik} \geq 0$.*

In the short-run analysis, the number of firms in each country, 1, 2, and 3 is assumed to be exogenously fixed; however, in the long-run analysis, the number of firms in exporting countries 1 and 2 is assumed to be exogenously fixed, while that in importing country 3 is assumed to be endogenously determined.

In the short-run analysis, we consider the following two-stage game. In the first stage, each exporting country government simultaneously determines its subsidy level $s_i (i = 1, 2)$. In the second stage, all firms compete Cournot in country 3's market. In the long-run analysis, however, we consider the following three-stage game: The first stage is the same as that in the short-run analysis. In the second stage, each domestic firm in country 3, a potential entrant, determines whether to enter its domestic market. In the third stage, all firms compete Cournot in country 3's market. Using backward induction, we solve the above games.

7.3 Short-Run Analysis

In this section, we try to obtain the short-run equilibrium. We consider the second-stage subgame. Given the export subsidy rate (s_j) in country $j(= 1, 2)$ and the number of firms in each country $n_i (i = 1, 2, 3)$, all firms compete *a là* Cournot in country 3's market.

In an exporting country $j(= 1, 2)$, the profit of a firm $k(= 1, 2, \ldots, n_j)$ is described by

$$\pi_{jk} = p(Q)q_{jk} - c_j(q_{jk}) + s_j q_{jk}. \tag{7.1}$$

From (7.1), the profit-maximizing condition for each firm in country i is given by

$$p'(Q)q_{jk} + p(Q) - c_j'(q_{jk}) + s_j = 0. \tag{7.2}$$

We focus on the semi-symmetric equilibrium, i.e., $q_{jk} = q_j = q_j(s_1, s_2)$.

In importing country 3, the profit of a firm $k(= 1, 2, \ldots, n_3)$ is given by

$$\pi_{3k} = p(Q)q_{3k} - c_3(q_{3k}) - F, \tag{7.3}$$

where $F(> 0)$ is a fixed entry cost. Assuming semi-symmetric equilibrium, $q_{3k} = q_3$, the profit-maximizing condition for each firm in country 3 is

$$p'(Q)q_3 + p(Q) - c_3'(q_3) = 0, \tag{7.4}$$

which is derived from (7.3). In the first stage, each exporting country government sets its subsidy rate s_j to maximize the level of its welfare

$$W_j = n_j(p(Q)q_j - c_j(q_j)). \tag{7.5}$$

The welfare-maximizing condition for country j is derived from (7.5):

$$\frac{\partial W_j}{\partial s_j} = n_j\left[p'q_j\frac{\partial Q}{\partial s_j} - (p - c_j')\frac{\partial Q_j}{\partial s_j}\right] = 0, \tag{7.6}$$

where $\frac{\partial Q}{\partial s_j} = \sum_{i=1}^{3} n_i \frac{\partial q_i}{\partial s_j}, j = 1, 2$. From (7.2) and (7.6), we obtain the optimal subsidy level in the short-run equilibrium as follows:

$$s_j^{SR} = n_l p' q_j \frac{\frac{\partial q_l}{\partial s_j}}{\frac{\partial q_j}{\partial s_j}} + n_3 p' q_j \frac{\frac{\partial q_3}{\partial s_j}}{\frac{\partial q_j}{\partial s_j}} + n_j p' q_j \left(1 - \frac{1}{n_j}\right) \tag{7.7}$$

for $(j, l) = (1, 2)$ and $j \neq l$.[4] The optimal subsidy rate in the short-run equilibrium s_j^{SR}. has to satisfy (7.7). The equation (7.7) corresponds to (A-8) in Krishna and Thursby (1991). The first term on the right-hand side (RHS) represents the *strategic distortion* for the rival exporting firms. The second term is the *strategic distortion* for the importing country's firms, whereas the third term shows the *terms of trade distortion*.

The strategic distortion is as follows: a country's subsidy enhances its firms' outputs, with a decrease in rival firms' outputs through strategic substitutability. Therefore, a country's subsidy enhances its firms' profits as well as its own welfare. The terms of trade distortion are as follows: a country's subsidy enhances its firms' outputs, which causes a decrease in market price. Price reduction brings about a decrease in its firms' profits.

From (7.7), we establish the following result:

Proposition 7.1 *Suppose that the entry of the importing country's firms occurs. If the sum of the strategic distortion for the firms in the rival exporting country and that in the importing one dominates (is dominated by) the terms of trade distortion, then the optimal export subsidy level is positive (negative).*[5]

Whether the equilibrium subsidy is positive depends on the difference of the number of firms among countries. When the number of firms in a concerned exporting country is much greater (smaller) than that of the rival country's and the importing country's firms, the term of trade distortion dominates (is dominated by) the strategic distortion. From Proposition 7.1, therefore, the equilibrium subsidy rate in the concerned country is negative (positive).

[4]The derivation of (7.7) is shown in Appendix A.

[5]We assume that all firms in the exporting country are viable in the short-run equilibrium.

This result is similar to what Krishna and Thursby (1991) showed. The only difference between (7.7) and (A-8) in Krishna and Thursby (1991) is whether strategic distortion for the importing country's firms prevails. The entry of the importing country's firms enhances strategic distortion, implying that the entry is liable to make s_j^{SR} positive.

7.4 Long-Run Analysis

7.4.1 Third-Stage Subgame

Following Szidarovzky and Yakowitz (1977), we derive a fitting-in function from (7.2) as follows:

$$q_j = f_j(Q, s_j), \quad j = 1, 2. \tag{7.8}$$

In importing country 3, the profit of a firm $k(= 1, 2, \ldots, n_3)$ is given by (7.3), so that the profit-maximizing condition for each firm in country 3, assuming semi-symmetric equilibrium, $q_{3k} = q_3$ becomes (7.4). The equation (7.4) can also be transformed into the following fitting-in function as

$$q_3 = f_3(Q). \tag{7.9}$$

We examine the effect of a change in total output on the individual output of each country's firms. From (7.8), (7.9) we obtain

$$\frac{\partial f_i}{\partial Q} = -\frac{p''(Q)q_i + p'(Q)}{p'(Q) - c_j''(q_i)} < 0, \quad i = 1, 2, 3, \tag{7.10}$$

because of Assumptions 7.1 and 7.2. We also examine the effect of a change in s_j on the individual output of each exporting country's firms, that is,

$$\frac{\partial f_j}{\partial s_j} = -\frac{1}{p'(Q) - c_j''(q_j)} > 0. \tag{7.11}$$

from Assumptions 7.1 and 7.2.

7.4.2 Second-Stage Subgame

Each potential firm in importing country 3 has to pay setup cost F to enter the market in the second stage. From (7.8) and (7.9), we obtain

$$n_1 f_1(Q, s_1) + n_2 f_2(Q, s_2) + n_3 f_3(Q) = Q. \tag{7.12}$$

Using (7.12), we represent n_3 as

$$n_3 = \frac{Q - n_1 f_1(Q, s_1) - n_2 f_2(Q, s_2)}{f_3(Q)} \equiv n_3(Q, s_1, s_2). \tag{7.13}$$

Substituting (7.9) into (7.3) yields

$$\pi_3 = p(Q)f_3(Q) - c_3(f_3(Q)) - F \equiv \pi_3(Q). \tag{7.14}$$

Therefore, a dynamic adjustment process for entry and exit is shown in

$$\dot{n_3} = \frac{\partial n_3(Q, s_1, s_2)}{\partial Q}\dot{Q} \equiv \sigma \pi_3(Q).$$

In this equation, $\dot{n}$ and $\dot{Q}$ denote time derivatives of n and Q, respectively, and σ is a positive parameter representing the speed of adjustment.[6] Therefore, the equilibrium total output in the long run named Q^{LR} satisfies the zero-profit condition, that is,

$$\pi_3(Q) = p(Q)f_3(Q) - c_3(f_3(Q)) - F = 0. \tag{7.15}$$

The equation (7.15) implies that Q^{LR} is a function of F, and not that Q^{LR} is a function of $s_j (j = 1, 2)$. In other words, Q^{LR} is constant to the change in $s_j (j = 1, 2)$.

We now check the uniqueness of Q^{LR}. Differentiating (7.14) with respect to Q and considering (7.4) and (7.10) yield

$$\pi_3'(Q) = p'(Q)f_3(Q)\left[1 - \frac{\partial f_3(Q)}{\partial Q}\right] < 0.$$

Thus we obtain

Lemma 7.1 (Hayashibara et al. (2007, Lemma 2)) *The equilibrium total output in the long-run equilibrium Q^{LR} is uniquely determined if it exists.*[7] *The equilibrium level of total output Q^{LR} has no connection with subsidy rates (s_i).*[8]

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[6]From (7.10) and (7.13), the following result is derived: n_3 is an increasing function of Q, i.e., $\frac{\partial n_3}{\partial Q} > 0$.

[7]If $\pi_3(Q) > 0$ when $n_3 = 1$ and if there exists $\bar{Q}$ such that $p(\bar{Q}) = c_3'(0)$, then Q^{LR} exists.

[8]We assume that at least one importing firm exists in the market in the long-run equilibrium. We also assume that all firms in the exporting country are viable.

7.4.3 First-Stage Subgame

In the first stage, each foreign exporting country's government sets its subsidy level s_j to maximize its welfare defined as

$$W_j = n_j[p(Q)f_j(Q, s_j) - c_j(f_j(Q, s_j))] \quad \text{for} \quad j = 1, 2. \tag{7.16}$$

Considering Lemma 7.1, we derive the welfare-maximizing condition in the long-run equilibrium from (7.11) and (7.16):

$$\begin{aligned} \left.\frac{\partial W_j}{\partial s_j}\right|_{Q=Q^{LR}} &= n_j p(Q^{LR}) \frac{\partial f_j(Q^{LR}, s_j)}{\partial s_j} - c_j'(f_j(Q^{LR}, s_j)) \frac{\partial f_j(Q^{LR}, s_j)}{\partial s_j} \\ &= -\frac{n_j \left[p(Q^{LR}) - c_j'(f_j(Q^{LR}, s_j))\right]}{p'(Q^{LR}) - c_j''(f_j(Q^{LR}, s_j))} = 0. \end{aligned} \tag{7.17}$$

Welfare-maximizing condition (7.17) can be transformed into

$$p(Q^{LR}) = c_j'(f_j(Q^{LR}, s_j)). \tag{7.18}$$

Therefore, the pair of the optimal subsidy rate in country j, i.e., (s_1^{LR}, s_2^{LR}), satisfies (7.18). Substituting (7.18) into (7.2) and evaluating at (s_1^{LR}, s_2^{LR}) yield

$$s_j^{LR} = -p'(Q^{LR})f_j(Q^{LR}, s_j^{LR}). \tag{7.19}$$

From (7.18) and (7.19), thus, we establish:

Proposition 7.2 (Hayashibara et al. (2007, Proposition 2)) *In the long-run equilibrium, the optimal subsidy rate brings about marginal cost pricing and is always positive.*

The key to understanding Proposition 7.2 is that the total output is solely determined by the zero-profit condition.[9] The equilibrium price is also determined by the firms' conditions, implying that each oligopolistic firm could be regarded as a price taker in equilibrium. Since the exporting country's welfare is the sum of profits, marginal cost pricing is desirable for the country's welfare viewpoint. Thus, the country's government subsidizes its firms so as to solve the insufficient production stemming from imperfect competition.

[9] Matsumura and Kanda (2005) derived similar results from a mixed oligopoly model with private firms' free entry. They pointed out that total output does not depend on any partial privatization level.

7.5 Main Results

The result in the long run is quite different from the result in the short run. The difference of the number of firms among the three countries plays a role in the determination of subsidy rate in the short run, while it is irrelevant in the long run. In the short run, government intervention (subsidy or tax) can change the price level because all firms are price makers in equilibrium. Since this change influences the profitability of each firm, both the strategic distortion and the terms of trade distortion prevail. The difference of the number of firms is an important factor in determining the scale of these two distortions. Thus, the differences play a role in the determination of the subsidy rate. In the long run, however, the total output level (price level) is solely determined by the entry behavior of the third country's firms. This means that these two distortions disappear in equilibrium because government intervention cannot indirectly control price level. It implies that the differences do not play a role in the determination of subsidy rate. Thus we summarize:

Proposition 7.3 *The difference in the number of firms among countries does not affect the equilibrium subsidy rate or the equilibrium price in the long run.*

Proposition 7.3 gives an implication about antitrust policy in the exporting countries. The exporting country's market structure depends on the degree of rigidity of the antitrust policy. Since intra- or intercountry's horizontal mergers change the number of exporters, if the antitrust policy becomes tough (loose) in an exporting country, then horizontal mergers slightly (drastically) reduce the number of exporters. In the short run, this reduction affects the equilibrium price through the change in the subsidy rate, while this does not affect the equilibrium price in the long run. In other words, whether the antitrust policy's degree of rigidity in exporting countries is tough or loose does not affect the equilibrium price in the long run.

As Ohkawa et al. (2002) pointed out, the differences play an important role in the endogenous timing of subsidy policy implementation in the short run. They concluded that the government in the exporting country with a smaller number of firms becomes a first mover subsidizing its firms, and the government in the country with a larger number of firms becomes a second mover imposing tax on its firms; i.e., the sequential timing is endogenously determined. In addition to this, the equilibrium outcome in the simultaneous move is different from that in the sequential move given the number of firms. In the long-run equilibrium, however, the strategic interaction between s_1 and s_2 does not prevail because the determination of the equilibrium price is independent from the subsidy rate. This implies that the long-run equilibrium outcome does not depend on whether policy timing is a simultaneous move. In other words, the equilibrium subsidy rate in a simultaneous move is the same as that in a sequential one. Since the quantity supplied by each firm in country j, q_j, is determined by Q^{LR} and s_j from (7.8), q_j is also irrelevant to policy timing. From (7.13), n_3^{LR} is also determined by total output Q^{LR} and s_j. Thus, we summarize the above result:

Proposition 7.4 *In the long-run equilibrium, the equilibrium subsidy rate is irrelevant to policy timing, and the equilibrium outcomes are also irrelevant to policy timing.*

Proposition 7.4 means that the level of welfare does not depend on the timing of policy implementation in the long-run equilibrium. It is quite different from the result in the short-run equilibrium.

Note that even if the subsidy rate s_j is exogenously determined, Lemma 7.1 holds because the number of firms in country 3 is determined after the pair of s_j, (s_1, s_2) is determined. This means that the equilibrium total output level Q^{LR} is irrelevant to any pair (s_1, s_2) such that country 3's firms can be viable. Specifically, the long-run equilibrium price level is unaffected by whether a government intervention is unilateral or bilateral, whether it selects export subsidy or export tax, and whether it intervenes or not in the market. This is a striking result. Thus we summarize:

Proposition 7.5 *In the long-run equilibrium, the price level under government intervention is the same as that under no intervention (free trade).*

Since policy implementation does not affect the equilibrium price, neither does it affect the level of welfare in the importing country 3 in the long-run equilibrium, because the importing country's welfare is defined as the sum of consumer and producer surpluses, i.e.,

$$W_3 = \left[\int_0^Q p(s)ds - p(Q)Q\right] + n_3(Q)[\pi_3(Q) - F]. \tag{7.20}$$

Results similar to those mentioned above hold in the situation where the government in exporting country 1 intervenes unilaterally and where the number of firms in exporting country 2 is also endogenously determined. This result is essentially the same as Etro's (2011), which showed the statement of Lemma 7.1 in a different situation.[10]

Certainly the total output level does not depend on the pair of subsidy rate (s_1, s_2), but the equilibrium number of firms n_i^{LR} does. From (7.11) and (7.13), we derive

$$\frac{\partial n_3^{LR}}{\partial s_j} = -\frac{n_j}{f_3(Q^{LR})}\frac{\partial f_j(Q^{LR}, s_j)}{\partial s_j} < 0. \tag{7.21}$$

The equation (7.21) shows that subsidizing exporting firms reduces the number of entrants into country 3's market. Thus we summarize:

[10] Etro's (2011) original model is as follows: There are n exporting countries. One exporting firm exists in each country. All exporting firms supply their products in an international market. Country 1's government alone subsidizes its firm. The number of exporting firms n is endogenously determined.

Proposition 7.6 *Government intervention affects the equilibrium number of country 3's firms.*

Proposition 7.6 states that the equilibrium number of country 3's firms under the implementation of an export subsidy is smaller than that under free trade.

7.6 Introduction of Tariff

7.6.1 Derivation of Long-Run Equilibrium

We will introduce into our model a specific tariff whose rate is t imposed on all exporting firms. This extension enables us to compare the results in the short-run analysis, i.e., Hayashibara (2002), with those in the long-run analysis.

Our original multistage game is revised as follows: In the first stage, each exporting country's government simultaneously determines its subsidy level $s_i (i = 1, 2)$. In addition, the importing country's government imposes its specific tariff t on exporting firms. In the second stage, each domestic firm in country 3, a potential entrant, determines whether to enter its domestic market. All firms compete Cournot in country 3's market in the third stage. For simplicity, we assume that the production technology of a firm in country 1 is the same that of a firm in country 2, i.e., $c_1(\cdot) = c_2(\cdot) = c(\cdot)$. Using backward induction, we solve the above game.

In the third stage, a firm k's profit in an exporting country $j(= 1, 2)$ is rewritten as[11]

$$\pi_{jk} = p(Q)q_{jk} - c(q_{jk}) + s_j q_{jk} - t q_{jk}. \tag{7.22}$$

From (7.22), the profit-maximizing condition for each firm in country j is given by

$$p'(Q)q_{jk} + p(Q) - c'(q_{jk}) + s_j - t = 0. \tag{7.23}$$

Assuming semi-symmetric equilibrium, the fitting-in function is given by

$$q_j = f_j(Q, s_j, t), j = 1, 2, \tag{7.24}$$

from (7.23). Note that, since a firm m's profit in importing country 3 is given by (7.3), the fitting-in function of firm m is also given by (7.9). From (7.24), we derive the effect of t on the individual output q_j:

$$\frac{\partial f_j}{\partial t} = \frac{1}{p'(Q) - c''(q_j)} > 0. \tag{7.25}$$

[11]Hereafter, for simplicity, we will assume that all exporting firms have the same technology.

We will solve the second-stage subgame. Since the equilibrium total output Q^* is determined by the zero-profit condition (7.15), the following result is obtained.

Lemma 7.2 *The equilibrium total output in the long-run equilibrium Q^* is uniquely determined if it exists. The equilibrium level of total output Q^* has no connection with either subsidy rates (s_i) or tariff rates (t).*

This result is similar to Lemma 7.1. Using the fitting-in functions, the number of firms in country 3 is described by

$$n_3 = \frac{Q - n_1 f_1(Q, s_1, t) - n_2 f_2(Q, s_2, t)}{f_3(Q)} \equiv n_3(Q, s_1, s_2, t). \tag{7.26}$$

Therefore, if the total output is determined, then the number of firms is also determined given the triplet (s_1, s_2, t) in the second-stage subgame.

In the first stage, each foreign exporting country's government sets its subsidy level s_j to maximize its welfare, defined as

$$W_j = n_j[p(Q)f_j(Q, s_j, t) - c(f_j(Q, s_j, t))] \quad \text{for } j = 1, 2. \tag{7.27}$$

Considering Lemma 7.2, we derive the welfare-maximizing condition in the long-run equilibrium from (7.11) and (7.27):

$$\begin{aligned} \left.\frac{\partial W_j}{\partial s_j}\right|_{Q=Q^*} &= n_j p(Q^*) \frac{\partial f_j(Q^*, s_j, t)}{\partial s_j} - (c_j' + t) f_j(Q^*, s_j, t) \frac{\partial f_j(Q^*, s_j, t)}{\partial s_j} \\ &= -\frac{n_j \left[p(Q^*) - c'(f_j(Q^*, s_j, t)) - t\right]}{p'(Q^*) - c''(f_j(Q^*, s_j, t))} = 0. \end{aligned} \tag{7.28}$$

Welfare-maximizing condition (7.28) can be transformed into

$$p(Q^*) = c'(f_j(Q^*, s_j, t)) + t. \tag{7.29}$$

In this stage, the importing country's government also chooses its tariff rate to maximize its welfare defined as the sum of consumer surpluses, producer surpluses, and tariff revenues, that is,

$$\begin{aligned} W_3 = &\left[\int_0^Q p(s)ds - p(Q)Q\right] + n_3(Q)[\pi_3(Q) - F] \\ &+ t\left[n_1 f_1(Q, s_1, t) + n_2 f_2(Q, s_2, t)\right]. \end{aligned} \tag{7.30}$$

In the long-run equilibrium, we obtain the welfare-maximizing condition for tariff imposition

$$\begin{aligned}\left.\frac{\partial W_3}{\partial t}\right|_{Q=Q^*} &= \sum_{j=1}^{2} n_j f_j(Q^*, s_j, t) + \sum_{j=1}^{2} n_j \frac{\partial f_j(Q^*, s_j, t)}{\partial t} \\ &= \sum_{j=1}^{2} n_j \left[f_j(Q^*, s_j, t) + \frac{t}{p'(Q^*) - c''(f_j(Q^*, s_j, t))} \right] = 0 \qquad (7.31)\end{aligned}$$

from Lemma 7.1, (7.25), and (7.16).

Therefore, the triplet of the optimal subsidy rate in country j and the optimal tariff rate, which is denoted by (s_1^*, s_2^*, t^*), satisfies (7.29) and (7.31). Substituting (7.29) into (7.23) and evaluating at (s_1^*, s_2^*, t^*) yield

$$s_j^* = -p'(Q^*) f_j(Q^*, s_j^*, t^*) + t^*. \qquad (7.32)$$

Since the equation (7.29) means that $q_1^* = q_2^*$, (7.31) can be rewritten as

$$t^* = -[p'(Q^*) - c''(f_j(Q^*, s_j^*, t^*))] f_j(Q^*, s_j^*, t^*), \qquad (7.33)$$

which is evaluated by (s_1^*, s_2^*, t^*). From (7.19) and (7.33), thus, we establish:

Proposition 7.7 *In the long-run equilibrium, both the optimal subsidy rate and the optimal tariff rate are always positive. The former is larger than the latter.*

7.6.2 Short-Run Equilibrium vs. Long-Run Equilibrium

We compare the equilibrium subsidy and tariff rates in the short run with those in the long run. Hayashibara (2002) constructed the following two-country model in a linear economy: firms in a foreign country and in a domestic country compete in the domestic market; each foreign country's government subsidizes its firms, and the domestic one imposes a tariff on the foreign firms. His model corresponds to our model with $n_2 = 0$. According to Hayashibara (2002), if the policy timing is simultaneous, then the equilibrium subsidy and tariff rates are

$$s_1 = \frac{(c_3 - c_1)(n_3 + 1 - n_1)}{n_1 + n_3 + 1},$$

$$t = \frac{(c_3 - c_1)(n_3 + 1)}{n_1 + n_3 + 1}.$$

Since Hayashibara (2002) assumed that $c_3 > c_1$, the sign of the equilibrium subsidy depends on the differences in the number of firms between countries 1 and 3, while the sign of the equilibrium tariff is positive.[12] In addition, even if $s_1 > 0$, the equilibrium subsidy rate is less than the equilibrium tariff rate. These results are different from Proposition 7.7.

Next, we examine the equilibrium total output (the equilibrium price). Since the number of country 3's firms is given in the short run, we derive from (7.26) as

$$Q = \sum_{j=1}^{2} n_j f_j(Q, s_j, t) + n_3 f_3(Q) = Q(s_1, s_2, t). \tag{7.34}$$

The above equation indicates that strategic interaction of policy implementation among three countries' governments emerges in the short-run equilibrium. Thus, the impact of the rent shifting effect through trade policy implemented by each country's government depends on the differences in the numbers of firms among three countries in the short-run equilibrium.

In the long-run equilibrium, strategic interaction of bilateral intervention implemented by two exporting countries' governments does not occur, but rather strategic interaction between the importing country government and each exporting country government as shown in (7.19) and (7.33). However, the equilibrium price is independent of both the differences and the timing in the long run as shown in (7.15).

Thus, we establish:

Proposition 7.8 *In the short run, therefore, the equilibrium price depends on the differences in the number of firms among three countries as well as the timing of policy implementation, while the equilibrium price does not depend on these factors.*

7.6.3 Effect of Tariff on the Long-Run Equilibrium

In this subsection, we examine first whether the introduction of a tariff alters the results mentioned above. We consider the equilibrium subsidy rate. The equation (7.29) means that the provision of the optimal subsidy enables each oligopolistic exporter to set its price at "effective" marginal cost, i.e., production marginal cost plus tariff rate. Thus, we summarize:

Proposition 7.9 *In the long-run equilibrium, each exporting country government sets a positive subsidy rate such that each exporter can attain its equilibrium outcome when it adopts "effective" marginal cost pricing.*

We also compare the equilibrium price under the implementation of a tariff policy with that under free trade. Because the determination of equilibrium total

[12]These equations are shown in Hayashibara (2002, p. 79). Note that domestic production subsidy is considered in Hayashibara's (2002) model, which is regarded as our setting with the cost differences among firms considered essential.

output in the long run has no connection with any tariff-subsidy schemes, whether governments intervene in the market does not affect the equilibrium total output or the equilibrium price in the long run. Thus, the introduction of a tariff does not affect the statement in Proposition 7.5.

Proposition 7.5 implies that consumer surplus under government intervention is equal to that under free trade. The introduction of a tariff adds the tariff revenue to the importing country's welfare through rent shifting. Clearly, the level of the importing country's welfare under the tariff policy is greater than that under free trade in the long-run equilibrium. Thus, we summarize:

Proposition 7.10 *The introduction of a tariff does not alter the statement in Proposition 7.5 and enhances the importing country's welfare through tariff revenue.*

7.7 Conclusion

In this chapter, we considered the three-country framework with the entry of the third importing country's firms, which is an extension of the model used by Brander and Spencer (1985) and Krishna and Thursby (1991). This framework is expressed as a three-stage game consisting of the stage of the subsidy rate determination, the stage of the determination of the number of the importing country's firms, and the stage of Cournot competition.

The main results in this chapter are as follows: (1) In the short-run equilibrium, the strategic interaction of policy variables through price change occurs, whereas in the long-run equilibrium, strategic interaction vanishes; i.e., strategic independence prevails. (2) Owing to strategic independence, the optimal subsidy rate brings about marginal cost pricing in the long run. (3) Strategic independence brings about the irrelevance result: the equilibrium outcome does not depend on the timing of subsidy policy implementation or the differences of the number of firms among three countries in the long run. (4) Strategic independence allows the equilibrium price under government intervention to equal that in under free trade. We extend our model by introducing an import tariff in the first stage and show that (5) even if both the import tariff and the export subsidy are implemented, the equilibrium price is the same level as that under free trade in the long run.

We point out an extension for further research. First, our model may be extended through endogenous determination of the number of both the exporting countries and the importing country. In this extended model, we can examine whether the above results hold or not.

Acknowledgements This work was supported by Grants-in-Aid for Scientific Research (no. 23530303 and 26380340). All remaining errors are ours.

Appendix

A. Derivation of (7.7)

From (7.2), we have $p - c' = -p'q_j - s_j$. Substituting this into (7.6) yields

$$p'q_j \frac{\partial Q}{\partial s_j} - (p'q_j + s_j)\frac{\partial q_j}{\partial s_j} = 0.$$

The above equation can be translated into

$$p'q_j \left[n_j \frac{\partial q_j}{\partial s_j} + n_k \frac{\partial q_k}{\partial s_j} + n_3 \frac{\partial q_3}{\partial s_j} \right] - (p'q_j + s_j)\frac{\partial q_j}{\partial s_j} = 0$$

$$p'q_j \left[n_k \frac{\frac{\partial q_k}{\partial s_j}}{\frac{\partial q_j}{\partial s_j}} + n_3 \frac{\frac{\partial q_3}{\partial s_j}}{\frac{\partial q_j}{\partial s_j}} \right] - s_j + n_j p' q_j \left(1 - \frac{1}{n_j} \right). \tag{A7.1}$$

From (A7.1), we easily derive (7.7).

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Chapter 8
Optimum Welfare and Maximum Revenue Tariff Under Oligopoly: A Note

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Abstract In this chapter, we extend the work of Collie (Scott J Political Econ 38:398–401, 1991) and Wang and Lee (Res Econ 66:106–109, 2012), comparing tariffs, outputs, and welfare under optimum welfare and maximum revenue situations. Our main conclusions are as follows. Under no new firm entry or exit, the difference between the optimum welfare and maximum revenue tariffs is a decreasing function of the cost difference between a domestic and foreign firm. There is a cutoff value of the cost difference such that the optimum welfare and maximum revenue tariffs are equal, which determines rankings for tariffs, outputs, and welfare. Under free entry of foreign firms, the difference between the optimum welfare and maximum revenue tariffs is a decreasing function of the cost difference between a domestic and foreign firm. Again, there is a cutoff value of the cost difference such that the optimum welfare and maximum revenue tariffs are equal, which determines tariff rankings. However, under free entry of domestic firms with asymmetric costs, the optimum welfare and maximum revenue tariffs are equal.

Keywords Optimum welfare tariff • Maximum revenue tariff • Cournot oligopoly • Free entry

8.1 Introduction

Governments in many countries, especially developing counties, have an incentive to use import tariffs to protect and/or promote targeted domestic industries, thereby improving national welfare or tariff revenue. Tariff rates can refer to either the maximum revenue tariff or the optimum welfare tariff if the government's goal is to maximize either tariff revenue or national welfare, respectively.

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*, New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_8

In a competitive international market, a large country can change its terms of trade through tariffs to improve national welfare or tariff revenue. The question then arises of whether the maximum revenue tariff or the optimum welfare tariff should be higher. The proposition that the maximum revenue tariff exceeds the optimum welfare tariff was demonstrated by Johnson (1951–1952). Collie (1991) explains the ranking between two tariff rates as follows: "an increase in the tariff beyond the maximum revenue rate will reduce tariff revenue and increase the price of imports, which reduces consumer surplus. This will have a negative effect on welfare, and hence the optimum welfare tariff cannot exceed the maximum revenue tariff."

Collie (1991) also shows that under two-country models with imperfect competition, firms can earn pure profits, which are one component of national welfare, and the optimum welfare tariff may exceed the maximum revenue tariff owing to the profit-shifting effect. The main result Collie obtains is that in a homogeneous product Cournot duopoly model with linear demand and constant marginal cost, the optimum welfare tariff may exceed the maximum revenue tariff under reasonable conditions, such as equal domestic and foreign marginal cost. Wang and Lee (2012) extend the work of Collie (1991) on the Cournot duopoly to the Cournot oligopoly and examine the rankings of the maximum revenue tariff and optimum welfare tariff under a linear Cournot oligopoly model with and without free entry of domestic firms. (See also Larue and Gervais (2002)). They demonstrate that in a regulated entry oligopoly with asymmetric costs, when the marginal cost of domestic firms exceeds a critical value, the maximum revenue tariff exceeds the optimum welfare tariff. They also conclude that under free entry of domestic firms with asymmetric costs, when the fixed cost increases and the number of domestic firms decreases, the difference between the optimum welfare tariff and the maximum revenue tariff increases.

However, the analysis of Wang and Lee (2012) leaves a couple of unanswered questions. First, under free entry of domestic firms with asymmetric costs, the difference between the optimum welfare tariff and the maximum revenue tariff is shown to vanish. Second, there is the question of what will happen under free entry of foreign firms, as Etro (2014) investigates, instead of domestic firms. We add the case of free entry of foreign firms with asymmetric costs and show the ranking of the maximum revenue tariff and optimum welfare tariff.

We extend the work of Collie (1991) and Wang and Lee (2012), comparing the tariff, outputs, and welfare under optimum welfare and maximum revenue in two directions, where one direction involves the case of an exogenously given number of firms and a short-run analysis and the other involves the case of an endogenously determined number of either domestic or foreign firms and a long-run analysis.

Our conclusions are as follows. First, in the short-run analysis, the difference between the optimum welfare tariff t^W and maximum revenue tariff t^R is a decreasing function of cost difference c between a domestic and foreign firm. There exists a cutoff value c^* of the cost difference c such that $t^W = t^R$ holds, which determines the rankings not only for tariffs but also for outputs and welfare. In Proposition 8.1, this c^* is increasing in a number of domestic firms and decreasing in a number of foreign firms. Thus, the optimum welfare tariff exceeds the maximum revenue tariff provided $c^* > c$. Proposition 8.2 demonstrates that the domestic firm's output is lower under the optimum welfare than the maximum revenue, and both the exporting firm's output and total output are higher under optimum welfare than under maximum revenue, provided the optimum welfare tariff is lower than the maximum revenue tariff. Proposition 8.3 states that, by definition, importing country welfare is always higher under optimum welfare than under maximum revenue. Both exporting country welfare and global welfare are higher under optimum welfare than under maximum revenue, provided the optimum welfare tariff is lower than the maximum revenue tariff.

Second, in the long-run analysis, Proposition 8.4 states that the optimum welfare tariff and the maximum revenue tariff are equal under free entry of domestic firms. This result is consistent with Etro (2014), a neutrality result, but differs from the results of Wang and Lee (2012). However, Proposition 8.5 shows that the difference between the optimum welfare tariff and the maximum revenue tariff under free entry of foreign firms is a decreasing function of cost difference c. There exists a cutoff value $\tilde{c}^*$ of the cost difference c, which is increasing with the number of domestic firms and with the fixed costs of foreign firms. Thus, the optimum welfare tariff exceeds the maximum revenue tariff provided $\tilde{c}^* > c$. Proposition 8.5 can be an extension of a dynamic situation of Proposition 8.1 given by Wang and Lee (2012). Etro (2014) shows the optimum tariff under conditions of no cost difference between domestic and foreign firms but does not show the maximum revenue tariff.

The remainder of this chapter is organized as follows. Basic modeling is provided in Sect. 8.2. Section 8.3 contains analysis of tariff ranking, output ranking, and welfare ranking where firm entry is regulated, while in Sect. 8.4, tariff ranking is analyzed under free entry of either domestic firms or foreign firms. Section 8.5 provides concluding remarks.

8.2 Basic Model

8.2.1 Setup

We consider a two-country model in which n identical home firms and m identical foreign firms compete in the domestic market in a Cournot fashion. The home government can use a tariff.

The home (importing) country's household utility function $U(Q, Z)$ is differentiable and strictly concave in Q:

$$U(Q, Z) = aQ - \frac{bQ^2}{2} + Z, \quad 0 < a, \ 0 < b,$$

where Q and Z are consumption of a good and the numeraire good z. From the first-order condition for utility maximization by a household, we obtain the linear inverse demand function:

$$p = a - bQ, \tag{8.1}$$

where p denotes the price of the good. Defining the consumer surplus as $CS = U - (pQ + Z)$, substitution obtains

$$CS = \frac{bQ^2}{2}. \tag{8.2}$$

Taking the governments' policies as given, each domestic or foreign firm produces q_1 and q_2, respectively. Thus $Q = nq_1 + mq_2$ holds. Let c_1 and c_2 be the marginal costs of the domestic firm and the foreign firm, respectively, and let F_1 and F_2 be their fixed costs. The net profit of each firm is

$$\pi_1 = (p - c_1)q_1 - F_1, \qquad \pi_2 = (p - c_2 - t)q_2 - F_2, \tag{8.3}$$

where t denotes a specific tariff on imports levied by the home government. Solving the first-order condition

$$p - c_1 - bq_1 = 0, \quad p - c_2 - t - bq_2 = 0, \tag{8.4}$$

the Cournot–Nash outputs are obtained as

$$q_1 = \frac{a - c_1 - m(c - t)}{b\Omega}, \quad q_2 = \frac{a - c_1 + (n + 1)(c - t)}{b\Omega}, \tag{8.5}$$

$$Q = \frac{(a - c_1)(n + m) + m(c - t)}{b\Omega}, \tag{8.6}$$

where $\Omega = n + m + 1$ and $c = c_1 - c_2 \geq 0$.[1] We assume

$$-\frac{a - c_1}{n + 1} < c - t < \frac{a - c_1}{m}.$$

The profit of each firm can be expressed by its output as, $\pi_i = bq_i^2 - F_i$. The national welfare of the home country is assumed to be the sum of the consumer surplus, total net profit of domestic firms, and net government revenue:

$$W_1 = CS + n\pi_1 + tmq_2 = CS + n(p - c_1)q_1 + tmq_2 - nF_1. \tag{8.7}$$

[1]We assume c is nonnegative but also mention cases where it may be negative.

The national welfare of the foreign country can be defined as the net profit of the foreign firms, that is,

$$W_2 = m\pi_2 = m(p - c_2 - t)q_2 - mF_2. \tag{8.8}$$

Global welfare is defined as

$$W = W_1 + W_2. \tag{8.9}$$

Here, we give the imaginary global welfare-maximizing tariff as

$$t^{WW} = -\frac{a - c_1 + \{(n+1)^2 + nm\}c}{m}, \tag{8.10}$$

which is negative if $-\frac{a-c_1}{(n+1)^2+nm} < c$ holds but can be positive under $-\frac{a-c_1}{(n+1)^2} < c < -\frac{a-c_1}{(n+1)^2+nm}$.[2]

8.3 Optimum Welfare and Maximum Revenue Tariff Under a Fixed Number of Firms

In what follows, we set $a - c_1 = 1$ and $c = c_1 - c_2 = a - 1 - c_2$, so for a given a any increases in c increase exporting firm efficiency.

8.3.1 Optimum Welfare Tariff

Solving the first-order condition for welfare maximization for t

$$\frac{dW_1}{dt} = \frac{dCS}{dt} + \frac{d\{(p - c_1)nq_1\}}{dt} + \frac{d(tmq_2)}{dt} = 0 \tag{8.11}$$

gives the following optimum welfare tariff:

$$t^W = \frac{2n + 1 + \{(n+1)^2 - nm\}c}{2(n+1)^2 + m} = \frac{n}{n+1}bq_1^W + bq_2^W > 0, \tag{8.12}$$

where superscript W indicates the equilibrium value under the optimum welfare tariff. In equation (8.11), the first term is nonpositive consumer surplus effect, the

[2] See Brander and Spencer (1984) p. 203.

second term is nonnegative profit-shifting effect, and the third term is tariff revenue effect. Substituting equation (8.12) into equations (8.5), (8.7), and (8.8), we obtain

$$q_1^W = \frac{(2-mc)(n+1)}{b\{2(n+1)^2+m\}}, \quad q_2^W = \frac{1+(n+1)^2c}{b\{2(n+1)^2+m\}},$$
$$W_1^W = \frac{\{2n(n+2)+m\}+2mc+m(n+1)^2c^2}{2b\{2(n+1)^2+m\}} - nF_1, \tag{8.13}$$

and

$$W_2^W = \frac{m\{1+(n+1)^2c\}^2}{b\{2(n+1)^2+m\}^2} - mF_2 = mb[q_2^W]^2 - mF_2. \tag{8.14}$$

For positive production, we assume

$$-\frac{1}{(n+1)^2} < c < \frac{2}{m}.$$

8.3.2 *Maximum Revenue Tariff*

If the domestic government maximizes tariff revenue instead of national welfare, solving

$$\frac{d(tmq_2)}{dt} = 0 \tag{8.15}$$

for t gives the maximum revenue tariff as

$$t^R = \frac{1+(n+1)c}{2(n+1)} = \Omega b q_2^R > 0, \tag{8.16}$$

where superscript R indicates the equilibrium value under the maximum revenue tariff. Substituting equation (8.16) into equations (8.5), (8.7), and (8.8), we obtain

$$q_1^R = \frac{\{2(n+1)+m\}-m(n+1)c}{2b(n+1)\Omega}, \quad q_2^R = \frac{1+(n+1)c}{2b(n+1)\Omega},$$

$$\begin{aligned} W_1^R = {} & \frac{m^2(2n+3)(2n+1)+2m(4n^2+7n+1)(n+1)+4(n+2)(n+1)^2n}{8b\Omega^2(n+1)^2} \\ & + \frac{\{(2n+3)m+2(n+1)\}(n+1)mc}{8b\Omega^2(n+1)^2} \\ & + \frac{\{(4n+3)m+2(n+1)^2\}(n+1)^2mc^2}{8b\Omega^2(n+1)^2} - nF_1, \end{aligned} \tag{8.17}$$

and

$$W_2^R = \frac{m\{1+(n+1)c\}^2}{4b\Omega^2} - mF_2 = mb[q_2^R]^2 - mF_2. \tag{8.18}$$

Here, we assume that

$$-\frac{1}{n+1} < c < \frac{2(n+1)+m}{(n+1)m} = \frac{2}{m} + \frac{1}{n+1}.$$

Thus, for positive outputs under both tariffs t^W and t^R and free trade $t = 0$, the following relations must hold:

$$\max\left[-\frac{1}{(n+1)^2}, -\frac{1}{n+1}\right] < c < \min\left[\frac{1}{m}, \frac{2}{m}, \frac{2(n+1)+m}{(n+1)m}\right]$$

which implies

$$-\frac{1}{(n+1)^2} < c < \frac{1}{m}.$$

Here, we add some comments. Collie (2003) analyzes the effects of domestic and foreign mergers and shows that when the domestic country pursues an optimum trade policy, it always loses as a result of foreign mergers; that is, domestic welfare under the optimum welfare tariff (with production subsidy) increases with the number of foreign firms. A related question is the result when the domestic country pursues a maximum revenue tariff policy. Differentiating W_1^R with respect to m yields

$$\frac{dW_1^R}{dm} = \frac{[\{n^3+3(m+1)n^2+(5m+3)n+2m+1\}c+mn+2m+1-n^2)]\{1+c(n+1)\}}{4b\Omega^3(n+1)},$$

which means without an excessive number of domestic firms relative to foreign firms, domestic welfare under the maximum revenue tariff can be increasing with the number of foreign firms.

8.3.3 Comparisons

For tariff ranking, subtracting (8.16) from (8.12), we obtain

$$t^W - t^R = \frac{2(n+1)n - m - (2n+1)(n+1)mc}{2\{2(n+1)^2+m\}(n+1)} = \frac{(2n+1)m(c^* - c)}{2\{2(n+1)^2+m\}}, \tag{8.19}$$

where

$$c^*(n,m) = \{c : t^W = t^R\} = \frac{2(n+1)n - m}{(2n+1)(n+1)m}, \tag{8.20}$$

which is positive (negative), if $2(n+1)n > (<) m$ holds. Moreover, if we assume $m \geq 1$, then

$$1 - c^* = \frac{2(m-1)(n+1)n + m(n+2)}{(2n+1)(n+1)m} > 0.$$

Further,

$$c^* - \left[-\frac{1}{(n+1)^2}\right] = \frac{\{2(n+1)^2 + m\}n}{(2n+1)(n+1)^2 m} > 0.$$

Differentiations of c^* with respect to n and m give

$$\frac{dc^*}{dn} = \frac{(4n+3)m + 2(n+1)^2}{(2n+1)^2(n+1)^2 m} > 0, \quad \frac{dc^*}{dm} = -\frac{2n}{(n+1)m^2} < 0.$$

We can summarize the above results as:

Proposition 8.1 (Wang and Lee (2012)) *The difference between the optimum welfare tariff and maximum revenue tariff is a decreasing function of cost difference c. There exists a cutoff value c^* given in (8.20) of the cost difference c, which satisfies $-\frac{1}{(n+1)^2} < c^* < 1$ and is increasing in n and decreasing in m. Thus, the optimum welfare tariff exceeds the maximum revenue tariff provided $c^* > c$.*

Higher c, which means greater efficiency of an exporting firm, implies $t^W < t^R$.[3]

Corollary 8.1 (Wang and Lee (2012)) *The difference between the optimum welfare tariff and the maximum revenue tariff is $\frac{\{1-(n+1)c\}n}{2(n+2)(n+1)}$ under $n = m$. Thus $c^* = \frac{1}{n+1} > 0$.*

Corollary 8.2 (Collie (1991)) *The difference between the optimum welfare tariff and the maximum revenue tariff is $\frac{1-2c}{12}$ under international duopoly $n = m = 1$. Thus $c^* = \frac{1}{2} > 0$.*

Straightforward comparisons (omitted) of outputs (8.5) and (8.6) give:

Proposition 8.2 *The domestic firm's output is lower under optimum welfare than under maximum revenue, and both exporting firm output and total output are higher under optimum welfare than under maximum revenue, provided the optimum welfare tariff is lower than the maximum revenue tariff.*

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[3]See Collie (1991), p. 401 and Wang and Lee (2012), p. 108.

Welfare comparisons give

$$W_1^W - W_1^R = \beta_h(t^W - t^R)^2 \geq 0, \quad W_2^W - W_2^R = \beta_f(t^W - t^R),$$

$$W^W - W^R = \beta_w(t^W - t^R),$$

where

$$\beta_h = \frac{2(n+1)^2 + m}{2b\Omega^2} > 0,$$

$$\beta_f = -\frac{[2(n+2)(n+1) + 3m + \{(2n+3)m + 4(n+1)^2\}(n+1)c](n+1)m}{2b\{2(n+1)^2 + m\}\Omega^2} < 0,$$

$$\beta_w = -\frac{[8(n+1)^3 + 2(3n+4)(n+1)m + m^2 + \{8\Omega(n+1)^3 + (2n+1)m^2\}(n+1)c]m}{4b\{2(n+1)^2 + m\}(n+1)\Omega^2},$$

and $\beta_h(t^W - t^R) + \beta_f = \beta_w < 0$ holds. Thus we have:

Proposition 8.3 *By definition, importing country welfare is always higher under optimum welfare than under maximum revenue. Both exporting country welfare and global welfare are higher under optimum welfare than under maximum revenue provided the optimum welfare tariff is lower than the maximum revenue tariff; that is, they are higher if and only if* $c^* < c$.

Considering Proposition 8.1, a cutoff value c^* of cost difference determines rankings for tariff, outputs, and welfare. Under our assumption that c is nonnegative, $t^{WW} < 0$ holds, and thus both the optimum welfare tariff and the maximum revenue tariff exceed the world welfare-maximizing tariff. Global welfare is concave in t, and $t^{WW} < t^W$ implies the above result. Foreign country welfare is convex in t, and its minimum value occurs at $t = c + \frac{1}{n+1}$; furthermore, $q_2 > 0$ implies that $t < c + \frac{1}{n+1}$ must hold, which leads to Proposition 8.3.

8.4 Analysis for Endogenous Market Structure

We now consider the two cases under an endogenous market structure. Assume that $-\sqrt{bF_1} < c < \sqrt{bF_2}$ holds.

8.4.1 Case of Free Entry and Exit of Domestic Firms

Suppose that owing to the relatively higher fixed sunk cost for foreign firms, no new entry of foreign firms occurs. However, domestic firms are assumed to be able to enter or exit the domestic market. An equilibrium number of domestic firms must satisfy $\pi_1 = bq_1^2 - F_1 = 0$; then, by solving the zero-profit condition, we can obtain the equilibrium number of firms in an importing country as

$$\hat{n} = \frac{\sqrt{bF_1}}{bF_1}\{1-(c-t)m\} - (m+1), \quad with \quad \hat{q}_1 = \sqrt{\frac{F_1}{b}}, \tag{8.21}$$

which is increasing in t but decreasing in F_1, c, and m.[4] The "hat" on the variables indicates the free entry equilibrium of home firms. Substituting the equilibrium number of firms into the welfare of the importing country (8.7), we obtain

$$\widehat{W_1} = \frac{(1-\sqrt{bF_1})^2 + 2tm(c+\sqrt{bF_1}-t)}{2b}. \tag{8.22}$$

Here $t > 0$ and $\hat{q}_2 = \frac{c+\sqrt{bF_1}-t}{b} > 0$ implies $\frac{d\widehat{W_1}}{dm} > 0$, which means that under free entry equilibrium of domestic firms, domestic welfare increases with the number of foreign firms. Thus, domestic free entry policy can substitute for optimum trade policy in responding to foreign mergers.

Next, we calculate the optimum welfare tariff. Maximizing $\widehat{W_1}$ with respect to tariff t yields the maximum welfare tariff as

$$\hat{t}^W = \frac{\sqrt{bF_1}+c}{2} > 0, \tag{8.23}$$

which is positive if output $\hat{q}_2^W = \frac{\sqrt{bF_1}+c}{2b}$ is positive. Conversely, the tariff revenue under free entry is

$$tm\hat{q}_2 = \frac{tm(c+\sqrt{bF_1}-t)}{b}, \tag{8.24}$$

Thus, the maximum revenue tariff rate can be obtained as

$$\hat{t}^R = \frac{\sqrt{bF_1}+c}{2}, \tag{8.25}$$

which is the same as the maximum revenue tariff rate identified by Wang and Lee (2012).

Comparing (8.25) and (8.23), we obtain $\hat{t}^W = \hat{t}^R$, which leads to:

Proposition 8.4 *The optimum welfare tariff and maximum revenue tariff are equal under free entry of domestic firms.*

[4] Equation (8.21) in the text is the same as (13) in Wang and Lee (2012).

This result is consistent with Etro (2014) but different from Wang and Lee (2012). We investigate why the optimum welfare tariff and maximum revenue tariff coincide under free entry of domestic firms. Using the zero-profit condition, first-order condition (8.4), inverse demand function (8.1), and consumer surplus (8.2), as well as the domestic price, total supply and consumer surplus under free entry

$$\hat{p} = c_1 + \frac{F_1}{\hat{q}_1} = c_1 + \sqrt{bF_1} = a - b\widehat{Q}, \quad \widehat{Q} = \frac{1-\sqrt{bF_1}}{b}, \quad \widehat{CS} = \frac{(1-\sqrt{bF_1})^2}{2b},$$

are all independent of tariff rate and national number of firms. The first term on the right-hand side in equation (8.22) denotes a consumer surplus under free entry of domestic firms and is independent of tariff rate, which implies the optimum welfare tariff equals the maximum revenue tariff.

8.4.2 Case of Free Entry and Exit of Foreign Firms

Etro (2014) investigates the case of domestic monopoly or fixed number of domestic firms, facing the endogenous entry of foreign (international) firms under symmetric costs, and derives the optimum welfare tariff. In this subsection, we will compare the optimum welfare tariff and maximum revenue tariff under asymmetric costs and numerous domestic firms. An equilibrium number of foreign firms must satisfy $\pi_2 = bq_2^2 - F_2 = 0$, and then by solving the zero-profit condition, we can obtain the equilibrium number of foreign firms as

$$\tilde{m} = \frac{\sqrt{bF_2}}{bF_2}\{1 + (c-t)(n+1)\} - (n+1), \quad \textit{with} \quad \tilde{q}_2 = \sqrt{\frac{F_2}{b}}, \tag{8.26}$$

which is increasing in c, but decreasing in F_2, t and n, if $\tilde{q}_1 = \frac{\sqrt{bF_2}-c+t}{b} > 0$. The "tilde" on the variables indicates the free entry equilibrium of foreign firms. Substituting the equilibrium number of firms $\tilde{m}$ into the welfare of the importing country (8.7), we obtain

$$\widetilde{W_1} = \frac{(1-\sqrt{bF_2}+c)^2 + 2n(\sqrt{bF_2}-c)^2 + 2n(\sqrt{bF_2}-c)t - t^2}{2b} - nF_1. \tag{8.27}$$

Maximizing $\widetilde{W_1}$ with respect to tariff t yields the maximum welfare tariff as

$$\tilde{t}^W = n(\sqrt{bF_2}-c) > 0, \tag{8.28}$$

which is increasing in both n and F_2, and positive, because we have $\tilde{q}_1^W = \frac{(n+1)(\sqrt{bF_2}-c)}{b} > 0$ and $\tilde{m}^W = \frac{1-(n+1)^2(\sqrt{bF_2}-c)}{\sqrt{bF_2}}$. Etro (2014) showed the maximum welfare tariff and domestic output for $c = 0$. The tariff revenue under free entry is

$$t\tilde{m}\tilde{q}_2 = \frac{t\{1-(n+1)(\sqrt{bF_2}-c+t)\}}{b}, \tag{8.29}$$

which is decreasing in both n and F_2. Thus, the maximum revenue tariff rate can be obtained as

$$\tilde{t}^R = \frac{1-(n+1)(\sqrt{bF_2}-c)}{2(n+1)} > 0, \tag{8.30}$$

which is decreasing with n and F_2, and positive if the number of foreign firms is positive because the number of foreign firms and the output of domestic firms can be shown by

$$\tilde{m}^R = \frac{1-(n+1)(\sqrt{bF_2}-c)}{2\sqrt{bF_2}}, \qquad \tilde{q}_1^R = \frac{1+(n+1)(\sqrt{bF_2}-c)}{2b(n+1)}.$$

Domestic output $\tilde{q}_1$ is increasing with t; thus, it is increasing with n under the optimum welfare tariff but decreasing with n under the maximum revenue tariff. Comparing (8.28) and (8.30), we obtain

$$\tilde{t}^W - \tilde{t}^R = \frac{(2n+1)(n+1)(\sqrt{bF_2}-c)-1}{2(n+1)} = \frac{(2n+1)(\tilde{c}^*-c)}{2}, \tag{8.31}$$

where

$$\tilde{c}^*(n, F_2) = \{c : \tilde{t}^W = \tilde{t}^R\} = \sqrt{bF_2} - \frac{1}{(n+1)(2n+1)}. \tag{8.32}$$

We can summarize the above results as:

Proposition 8.5 *The difference between the optimum welfare tariff and the maximum revenue tariff under free entry of foreign firms is a decreasing function of cost difference c and an increasing function of n and F_2. There exists a cutoff value $\tilde{c}^*$ given in (8.32) of the cost difference c, which is increasing in n and F_2. Thus, the optimum welfare tariff exceeds the maximum revenue tariff provided $\tilde{c}^* > c$.*

Proposition 8.5 can be an extension to a dynamic version of Proposition 8.1 given by Wang and Lee (2012).

8.5 Conclusions

We extended the work of Collie (1991) and Wang and Lee (2012), considering tariffs, outputs, and welfare under both optimum welfare and maximum revenue. The difference between the optimum welfare tariff t^W and maximum revenue tariff t^R is a decreasing function of cost difference c. There exists a cutoff value c^* of the cost difference c such that $t^W = t^R$ holds, which determines rankings for tariffs, outputs, and welfare. This c^* is increasing in some domestic firms and decreasing in some foreign firms.

The optimum welfare tariff and maximum revenue tariff are equal under free entry of domestic firms.

The difference between the optimum welfare tariff and maximum revenue tariff under free entry of foreign firms is a decreasing function of cost difference c and an increasing function of n and F_2. There exists a cutoff value $\tilde{c}^*$ of the cost difference c, which is increasing in some domestic firms, and the fixed cost of foreign firms F_2, which lowers the equilibrium number of foreign firms. Thus, the optimum welfare tariff exceeds the maximum revenue tariff provided $\tilde{c}^* > c$. This proposition can be an extension to a dynamic version of Proposition 1 given by Wang and Lee (2012).

Acknowledgements This work was supported by Grants-in-Aid for Scientific Research (no. 23530303 and 26380340). All remaining errors are mine.

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Chapter 9
Cost Asymmetries and Import Tariff Policy in a Vertically Related Industry

Yasushi Kawabata

Abstract This chapter examines the effects of the cost asymmetry of final goods production and the cost difference in intermediate goods production on the import tariffs on both goods imposed by two countries' governments in a model with vertically related markets characterized by Cournot duopolies. It is shown that the country with the highest-cost final (intermediate) goods firm may levy the lowest import tariff on the final (intermediate) goods.

Keywords Import tariff • Vertically related markets • Cournot duopoly

9.1 Introduction

There have been a number of theoretical studies analyzing trade policy games where home and foreign governments impose import tariffs (export subsidies or taxes) noncooperatively in models of imperfect competition. In the Brander and Spencer (1985) model where a home firm and a foreign firm compete in a Cournot duopoly in a third-country market, de Meza (1986) and Neary (1994) demonstrated that the country with the lowest-cost firm provides the largest export subsidy.[1] In the Eaton and Grossman (1986) model where a home and a foreign firm engage in a Bertrand duopoly in a third market, Clarke and Collie (2006) found that the country with the lowest-cost firm imposes the largest export tax. In the Appendix of this chapter, we show that in the Brander and Spencer (1984) model where a home and a foreign firm

[1]Bandyopadhyay (1997) showed that the result in de Meza (1986) and Neary (1994) is reversed for inelastic demand.

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*, New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_9

compete in a Cournot duopoly in segmented home and foreign markets, the country with the highest-cost firm imposes the largest import tariff.[2]

However, these studies overlooked one important aspect of world trade, namely, that global trade in intermediate goods has been expanding rapidly over the past two decades. According to Escaith and Inomata (2011), world exports of intermediate goods nearly doubled between 1995 and 2009, from around US$ 2,774 to US$ 5,373 billion, and in 2009, intermediate goods accounted for 51 % of world nonfuel merchandise exports. In East Asia, for example, intermediate goods such as parts and components are now actively traded among manufacturing bases located across the region. Thus, in designing trade policies, it is necessary for policymakers to consider the growing trade in intermediate goods. The question that arises is how the incorporation of an imperfectly competitive intermediate goods will affect the trade policy imposed by each country's government.[3]

The purpose of this chapter is to examine the effects of the cost asymmetry of final goods production and the cost difference in intermediate goods production on the import tariffs applied to both goods and imposed by the home and the foreign governments in a vertically related industry with a final goods and an intermediate goods sector.[4] We construct a model where a home and a foreign downstream (final goods) firm compete in a Cournot duopoly in the home and foreign downstream markets, and a home and a foreign upstream (intermediate goods) firm engage in a Cournot duopoly in the home and foreign upstream markets.

We provide the following findings. If the home upstream firm's costs are much smaller than the foreign upstream firm's costs, the home country will impose the lowest import tariff on the final goods, even if the home downstream firm has the highest costs. Further, if the home downstream firm's costs are sufficiently higher than the foreign downstream firm's costs, the home country will levy the lowest import tariff on the intermediate goods, even if the home upstream firm has the highest costs. The result in our model is that the country with the highest-cost downstream (respectively upstream) firm does not necessarily impose the largest tariff on the downstream (respectively upstream) imports. This is in contrast to the result in a model without an upstream sector, as shown in the Appendix. In our model with upstream and downstream sectors, there is not only a *horizontal* profit-extraction effect of the import tariff but also a *vertical* effect, and where the vertical

[2]Collie (1991, 1994) dealt with a trade policy game with foreign export subsidy and home import tariff in a model of Cournot competition.

[3]Kawabata (2012) examined how the conventional result in de Meza (1986) and Neary (1994) changes in a model of vertically related markets characterized by Cournot competition and showed that the country where the sums of the costs of final goods production and intermediate goods production are the lowest provides the largest production subsidies to the final goods and the intermediate goods.

[4]Studies concerning strategic trade policy in vertically related markets include Bernhofen (1997), Ishikawa and Spencer (1999), Chang and Sugeta (2004), Hwang et al. (2007), and Kawabata (2010).

effect outweighs the horizontal effect, the result in the absence of vertical industry relationships reverses.

The remainder of this chapter is organized as follows. Section 9.2 describes the model and derives the market equilibrium. Section 9.3 analyzes three trade policy games: (i) a game where the home and the foreign governments only use an import tariff on the final goods, (ii) a game where the two governments only use an import tariff on the intermediate goods, and (iii) a game where both governments use import tariffs on the final and the intermediate goods. Section 9.4 provides a conclusion.

9.2 Model

We consider a vertically related industry with an intermediate goods and a final goods sector in two countries, a home and a foreign country. Each country has one upstream firm that produces a homogeneous intermediate goods and one downstream firm that produces a homogeneous final goods. The home and the foreign upstream firms engage in Cournot competition in supplying the intermediate goods to the upstream markets in both countries. The home and the foreign downstream firms supply the final goods to home and foreign downstream markets, where they play Cournot competition.[5] The home and the foreign governments impose specific tariffs, t_1 and t_2, on intermediate goods imports and specific tariffs, T_1 and T_2, on final goods imports, respectively.

The model is characterized by a three-stage game. In stage 1, the home and the foreign governments determine their import tariffs on the intermediate and the final goods. In stage 2 with given tariffs, the home and the foreign upstream firms decide their outputs of the intermediate goods. In stage 3, given the home and foreign prices of the intermediate goods, the home and the foreign downstream firms decide their supplies of the final goods.[6] The intermediate goods price is simply the market-clearing price. The solution concept employed is a subgame perfect equilibrium, obtained by a process of backward induction.

9.2.1 Downstream Markets

Sales by the home and the foreign downstream firms in the home market are denoted y_{11} and y_{12}, respectively. Their respective sales in the foreign market are denoted y_{21}

[5]The markets in the two countries are assumed to be segmented.

[6]This setting implies that downstream firms have no market power as buyers of the intermediate goods even though they have market power as sellers of the final goods. This setting is often adopted in the literature on vertical trade (e.g., Bernhofen, 1995, 1997; Ishikawa and Lee 1997; Ishikawa and Spencer, 1999; Hwang et al., 2007; Kawabata, 2010). In particular, Ishikawa and Spencer (1999) discussed the justification for this setting in detail.

and y_{22}. The prices, p_1 and p_2, of the final goods in the home and foreign countries are determined by the inverse demand functions, $p_1(Y_1) = \alpha - Y_1$ and $p_2(Y_2) = \alpha - Y_2$, respectively, where $Y_i \equiv \sum_{j=1,2} y_{ij}$ $(i = 1, 2)$. We assume that the production of one unit of the final goods requires one unit of the intermediate goods. The cost of transforming one unit of the intermediate goods into one unit of the final goods is c_1 for the home downstream firm and c_2 for the foreign downstream firm.[7]

The profits of the home and the foreign downstream firms are given by

$$\pi_i^D = (p_i - r_i - c_i)\, y_{ii} + \left(p_j - r_i - c_i - T_j\right) y_{ji}, \quad i, j = 1, 2 \quad i \neq j \tag{9.1}$$

where r_1 and r_2 are the price of the intermediate goods in the home and the foreign countries, respectively.

We first set up the conditions determining the Cournot–Nash equilibrium in stage 3. Given r_1 and r_2, the first-order conditions for profit maximization by the home and the foreign downstream firms under the Cournot assumption are

$$p_i - r_i - c_i + y_{ii} p_i' = 0,$$
$$p_i - r_j - c_j - T_i + y_{ij} p_i' = 0, \quad i, j = 1, 2 \quad i \neq j. \tag{9.2}$$

By solving these conditions simultaneously, we obtain the downstream firms' Cournot–Nash equilibrium outputs:

$$y_{ii} = \frac{\alpha - 2(r_i + c_i) + r_j + c_j + T_i}{3},$$
$$y_{ij} = \frac{\alpha + r_i + c_i - 2\left(r_j + c_j + T_i\right)}{3}, \quad i, j = 1, 2 \quad i \neq j. \tag{9.3}$$

9.2.2 Upstream Markets

The home upstream firm sells x_{11} in the home market and x_{21} in the foreign market, while the foreign upstream firm sells x_{12} in the home market and x_{22} in the foreign market. The total supplies to the home and the foreign upstream markets are given by $X_1 \equiv \sum_{i=1,2} x_{1i}$ and $X_2 \equiv \sum_{i=1,2} x_{2i}$, respectively.

In stage 2, the home and the foreign upstream firms anticipate the derived demand for the intermediate goods that arises from the Cournot–Nash equilibrium in stage 3. From the market-clearing conditions in the two countries, i.e., $X_i = \sum_{j=1,2} y_{ji}$

[7]We can also assume that one unit of the intermediate goods together with one unit of a second input is required to produce one unit of the final goods and that, in the home (foreign) country, the second input is supplied to the downstream firm at an exogenously given price c_1 (c_2).

($i = 1, 2$), we can derive the inverse demand for the intermediate goods in the home and the foreign countries:

$$r_i\left(X_i, X_j\right) = \alpha - c_i - \frac{1}{2}T_j - X_i - \frac{1}{2}X_j, \quad i,j = 1,2 \quad i \neq j. \tag{9.4}$$

The home and the foreign upstream firms have constant marginal costs of producing the intermediate goods, k_1 and k_2, respectively. Their profits are given by

$$\pi_i^U = (r_i - k_i)\, x_{ii} + \left(r_j - k_i - t_j\right) x_{ji}, \quad i,j = 1,2 \quad i \neq j. \tag{9.5}$$

The first-order conditions for profit maximization by the home and the foreign upstream firms under the Cournot assumption are

$$\begin{aligned} r_i - k_i + x_{ii}\frac{\partial r_i}{\partial X_i} + x_{ji}\frac{\partial r_j}{\partial X_i} &= 0, \\ r_j - k_i - t_j + x_{ji}\frac{\partial r_j}{\partial X_j} + x_{ii}\frac{\partial r_i}{\partial X_j} &= 0, \quad i,j = 1,2 \quad i \neq j. \end{aligned} \tag{9.6}$$

By solving these conditions simultaneously, we obtain the equilibrium sales of the home and the foreign upstream firms:

$$\begin{aligned} x_{ii} &= \frac{2\alpha - 4\,(c_i + k_i) + 2\left(c_j + k_j\right) + 4\left(t_i + t_j\right) + T_i - 2T_j}{9}, \\ x_{ji} &= \frac{2\alpha - 4\left(c_j + k_i\right) + 2\left(c_i + k_j\right) - 2\,(t_i + T_i) - 8t_j + T_j}{9}, \quad i,j = 1,2 \quad i \neq j. \end{aligned} \tag{9.7}$$

From (9.4) and (9.7), the equilibrium prices of the intermediate goods in the home and the foreign countries are

$$r_i = \frac{2\alpha - 2c_i + 2\left(k_i + k_j\right) + 2t_i - T_j}{6}, \quad i,j = 1,2, \quad i \neq j. \tag{9.8}$$

By substituting (9.8) into (9.3), we have the equilibrium sales of the home and the foreign downstream firms:

$$\begin{aligned} y_{ii} &= \frac{4\alpha - 8c_i + 4c_j - 2\left(k_i + k_j\right) - 4t_i + 2\left(t_j + T_j\right) + 5T_i}{18}, \\ y_{ij} &= \frac{4\alpha + 4c_i - 8c_j - 2\left(k_i + k_j\right) + 2t_i - 4t_j - 10T_i - T_j}{18}, \quad i,j = 1,2 \quad i \neq j. \end{aligned} \tag{9.9}$$

From (9.9), the equilibrium total sales in the home and the foreign countries are thus

$$Y_i = \frac{8\alpha - 4\left(c_i + c_j + k_i + k_j\right) - 2\left(t_i + t_j\right) - 5T_i + T_j}{18}, \quad i,j = 1,2, \quad i \neq j. \tag{9.10}$$

9.3 Import Tariff Policy Game

This section examines the import tariff policies of the home and the foreign countries. In stage 1, the home and the foreign governments independently and simultaneously set their import tariffs on the intermediate and the final goods to maximize their own welfare, realizing the effects of their intervention on the firms' decisions in stages 2 and 3. We analyze three trade policy games: (i) a game where the home and the foreign governments only use an import tariff on the final goods, (ii) a game where the two governments only use an import tariff on the intermediate goods, and (iii) a game where both governments use import tariffs on the final and the intermediate goods.[8]

The welfare of each country is given by the sum of the profits of the downstream and upstream firms, consumer surplus, and tariff revenue:

$$W_i = \pi_i^D + \pi_i^U + CS_i + TR_i = \sum\nolimits_{j=1,2} \pi_{ji}^D + \sum\nolimits_{j=1,2} \pi_{ji}^U + CS_i + TR_i, \quad i = 1,2 \tag{9.11}$$

where $CS_i \equiv \int_0^{Y_i} p_i(s)\, ds - p_i(Y_i)\, Y_i$ denotes consumer surplus, $TR_i \equiv T_i y_{ij} + t_i x_{ij}$ denotes tariff revenue, and π_{1i}^k and π_{2i}^k $(k = D, U)$ denote the profits made by the downstream and upstream firms in the home and the foreign markets, respectively.

9.3.1 Trade Policy Game with Import Tariff on the Final Good

We begin with the case where the home and the foreign governments impose a tariff on final goods imports.[9] In the Nash equilibrium, each government maximizes its welfare given the import tariff on the final goods set by the other government. Thus,

[8]In the subsequent analysis, we assume that all upstream and downstream firms sell positive quantities in the home and foreign markets (i.e., $x_{ij} > 0$ and $y_{ij} > 0$, $i,j = 1,2$).

[9]In this subsection, we assume that the import tariff on the intermediate goods is zero (i.e., $t_1 = t_2 = 0$).

the first-order conditions for the Nash equilibrium are

$$\frac{\partial W_i}{\partial T_i} = \frac{\partial \pi_{1i}^D}{\partial T_i} + \frac{\partial \pi_{2i}^D}{\partial T_i} + \frac{\partial \pi_{1i}^U}{\partial T_i} + \frac{\partial \pi_{2i}^U}{\partial T_i} + \frac{\partial CS_i}{\partial T_i} + \frac{\partial TR_i}{\partial T_i} = 0, \quad i = 1, 2. \tag{9.12}$$

The first term in (9.12) is the effect of the tariff against final goods imports on the downstream firm's profits in the home market: an increase in the tariff T_1 imposed by the home government increases the domestic sales of the home downstream firm and its profits from the home market. The second term is the effect on the downstream firm's profits in the foreign market: an increase in T_1 decreases the exports of the home downstream firm and its profits in the foreign market. The third term is the effect on the upstream firm's profits in the home market: an increase in T_1 increases the domestic sales of the home upstream firm because of an increase in the derived demand for the intermediate goods in the home country, thereby increasing its local profits. The fourth term is the effect on the upstream firm's profits in the foreign market: an increase in T_1 decreases the exports of the home upstream firm and lowers the foreign price of the intermediate goods because of a decrease in the derived demand for the intermediate goods in the foreign country, thus reducing its profits from the foreign market.[10] The fifth term is the effect on consumer surplus: an increase in T_1 decreases the total sales of the final goods in the home country and thereby reduces its consumer surplus. The sixth term is the effect on the tariff revenue of the home government: an increase in T_1 raises (respectively reduces) tariff revenue from final goods imports for low (respectively high) tariffs.

Using (9.7), (9.8), (9.9), and (9.10) to solve (9.12) yields the Nash equilibrium import tariffs of both countries:

$$T_i = \frac{440\alpha + 34c_i - 474c_j + 161k_i - 601k_j}{2794}, \quad i, j = 1, 2 \quad i \neq j. \tag{9.13}$$

Using (9.13) to compare the Nash equilibrium import tariffs yields

$$T_1 - T_2 = \frac{2\,(c_1 - c_2) - 3\,(k_2 - k_1)}{11}. \tag{9.14}$$

If the home upstream firm produces at sufficiently smaller marginal costs than the foreign upstream firm, the home country may impose the lowest import tariff on the final goods, even if the home downstream firm is less efficient than the foreign downstream firm. This leads to the following proposition.

[10] From $\partial \pi_{1i}^U / \partial T_i + \partial \pi_{2i}^U / \partial T_i = -x_{ji}/3 < 0$, the negative effect of the home downstream tariff T_1 on the export profits of the home upstream firm outweighs the positive effect on its local profits; consequently, an increase in T_1 reduces the home upstream firm's profits.

Proposition 9.1 *Country i, whose downstream firm has the highest costs (i.e., $c_i > c_j$), imposes the lowest import tariff on the final goods (i.e., $T_i < T_j$) if and only if $\frac{2}{3}\left(c_i - c_j\right) < k_j - k_i$.*

We can explain the intuition behind Proposition 9.1 as follows. Suppose that the home downstream firm has a cost disadvantage (i.e., $c_1 > c_2$) and the home upstream firm has a cost advantage (i.e., $k_1 < k_2$). When $c_1 > c_2$, the foreign downstream firm's profits in the home market that the home government can extract with its downstream tariff T_1 are larger than the home downstream firm's profits in the foreign market that the foreign government can extract with its downstream tariff T_2. This leads the home government to have a greater incentive than the foreign government to impose a downstream tariff. However, when $k_1 < k_2$, the negative effect of the home downstream tariff T_1 on the home upstream firm's export profits is greater than that of the foreign downstream tariff T_2 on the foreign upstream firm's export profits because the home upstream firm's exports are larger than the foreign upstream firm's exports. This entails a weaker incentive for the home government to levy a downstream tariff than for the foreign government. If the cost difference, $k_2 - k_1$, between foreign and home upstream firms is sufficiently large, the *vertical* effect of the downstream tariff on the upstream firm's profits outweighs the *horizontal* profit-extracting effect. Therefore, the home government imposes the smallest downstream tariff, even if the home downstream firm has a cost disadvantage.

9.3.2 Trade Policy Game with Import Tariff on the Intermediate Good

We next turn to the case where both governments impose a tariff on intermediate goods imports.[11] The first-order conditions for the Nash equilibrium in import tariffs on the intermediate goods are

$$\frac{\partial W_i}{\partial t_i} = \frac{\partial \pi_{1i}^U}{\partial t_i} + \frac{\partial \pi_{2i}^U}{\partial t_i} + \frac{\partial \pi_{1i}^D}{\partial t_i} + \frac{\partial \pi_{2i}^D}{\partial t_i} + \frac{\partial CS_i}{\partial t_i} + \frac{\partial TR_i}{\partial t_i} = 0, \quad i = 1, 2. \tag{9.15}$$

The first term in (9.15) is the effect of the tariff against intermediate goods imports on the upstream firm's profits in the home market: an increase in the tariff t_1 imposed by the home government increases the domestic sales of the home upstream firm and raises the intermediate goods price in the home country, thereby increasing its local profits. The second term is the effect on the upstream firm's profits in the foreign market: an increase in t_1 decreases the exports of the home upstream firm and its

[11] In this subsection, we assume that the import tariff on the final goods is zero (i.e., $T_1 = T_2 = 0$).

profits from the foreign market.[12] The sum of the third and fourth terms is the effect on the downstream firm's profits: an increase in t_1 raises the marginal costs that the home downstream firm faces because of a rise in the home price of the intermediate goods, thus reducing its sales and profits in the home and foreign markets. The fifth term is the effect on consumer surplus: an increase in t_1 decreases the total sales of the final goods in the home country and its consumer surplus. The sixth term is the effect on the tariff revenue of the home government: an increase in t_1 raises (respectively reduces) tariff revenue from intermediate goods imports for low (respectively high) tariffs.

Using (9.7), (9.8), (9.9), and (9.10) to solve (9.15) yields the Nash equilibrium import tariffs[13]:

$$t_i = \frac{170\alpha - 449c_i + 279c_j + 71k_i - 241k_j}{1768}, \quad i,j = 1,2 \quad i \neq j. \tag{9.16}$$

Using (9.16) to compare the Nash equilibrium import tariffs yields

$$t_1 - t_2 = \frac{3\left(k_1 - k_2\right) - 7\left(c_1 - c_2\right)}{17}. \tag{9.17}$$

If the home downstream firm is significantly less efficient than the foreign downstream firm, the home country may levy the lowest import tariff on the intermediate goods, even if the home upstream firm's costs are higher than the foreign upstream firm's costs. This leads to the following proposition.

Proposition 9.2 *Country i, whose upstream firm has the highest costs (i.e., $k_i > k_j$), imposes the lowest import tariff on the intermediate goods (i.e., $t_i < t_j$) if and only if $\frac{3}{7}\left(k_i - k_j\right) < c_i - c_j$.*

We can explain the intuition behind Proposition 9.2 as follows. Suppose that the home upstream firm has highest costs (i.e., $k_1 > k_2$) and the home downstream firm has highest costs (i.e., $c_1 > c_2$). When $k_1 > k_2$, the foreign upstream firm's export profits for the home government to extract with its upstream tariff t_1 are greater than the home upstream firm's export profits for the foreign government to extract with its downstream tariff t_2. This induces a stronger incentive for the home government to levy an upstream tariff than for the foreign government. However, when $c_1 > c_2$, the foreign downstream firm's output and its derived demand for the intermediate goods are larger than those of the home downstream firm, so the foreign imports of the intermediate goods are greater than the home imports. This causes the foreign government's incentive for an upstream tariff to outweigh

[12]From $\partial\pi_{1i}^U/\partial t_i + \partial\pi_{2i}^U/\partial t_i = 2x_{ii}/3 > 0$, the positive effect of the home upstream tariff t_1 on the local profits of the home upstream firm outweighs the negative effect on its export profits; therefore, an increase in t_1 increases the home upstream firm's profits.

[13]The Nash equilibrium import tariff on the intermediate goods can be negative (an import subsidy) for one of the two countries.

that of the home government. If the cost difference, $c_1 - c_2$, between home and foreign downstream firms is significantly large, the *vertical* effect arising from a downstream sector dominates the *horizontal* profit-extracting effect. Consequently, the home government levies the lowest upstream tariff, even if the home upstream firm has the highest costs.

9.3.3 Trade Policy Game with Import Tariffs on the Final and the Intermediate Goods

We now consider the case where the home and the foreign governments impose tariffs on both final goods and intermediate goods imports. The first-order conditions for the Nash equilibrium in import tariffs on the final and the intermediate goods are

$$\frac{\partial W_i}{\partial T_i} = \frac{\partial \pi_{1i}^D}{\partial T_i} + \frac{\partial \pi_{2i}^D}{\partial T_i} + \frac{\partial \pi_{1i}^U}{\partial T_i} + \frac{\partial \pi_{2i}^U}{\partial T_i} + \frac{\partial CS_i}{\partial T_i} + \frac{\partial TR_i}{\partial T_i} = 0, \tag{9.18}$$

$$\frac{\partial W_i}{\partial t_i} = \frac{\partial \pi_{1i}^U}{\partial t_i} + \frac{\partial \pi_{2i}^U}{\partial t_i} + \frac{\partial \pi_{1i}^D}{\partial t_i} + \frac{\partial \pi_{2i}^D}{\partial t_i} + \frac{\partial CS_i}{\partial t_i} + \frac{\partial TR_i}{\partial t_i} = 0, \quad i = 1, 2. \tag{9.19}$$

The sixth term in (9.18) is the tariff revenue effect: in addition to the effect on tariff revenue from final goods imports (as mentioned in 9.3.1), an increase in T_1 increases imports of the intermediate goods, thereby raising tariff revenue from intermediate goods imports. The sixth term in (9.19) is the tariff revenue effect: in addition to the effect on tariff revenue from intermediate goods imports (as stated in 9.3.2), an increase in t_1 increases imports of the final goods, thus raising tariff revenue from final goods imports.

Using (9.7), (9.8), (9.9), and (9.10) to solve (9.18) and (9.19) yields the Nash equilibrium import tariffs:

$$T_i = \frac{1210\alpha - 173c_i - 1037c_j + 259k_i - 1469k_j}{5808}, \tag{9.20}$$

$$t_i = \frac{110\alpha - 247c_i + 137c_j + 89k_i - 199k_j}{1056}, \quad i, j = 1, 2 \quad i \neq j. \tag{9.21}$$

The differential between the two Nash equilibrium import tariffs on the final goods (9.20) is

$$T_1 - T_2 = \frac{18\left[(c_1 - c_2) - 2\left(k_2 - k_1\right)\right]}{121}. \tag{9.22}$$

The differential between the Nash equilibrium import tariffs on the intermediate goods (9.21) is

$$t_1 - t_2 = \frac{3\left(k_1 - k_2\right) - 4\left(c_1 - c_2\right)}{11}. \tag{9.23}$$

If the home upstream firm's costs are much lower than the foreign upstream firm's costs, the home country will levy the smallest import tariff on the final goods, even if the home downstream firm has a cost disadvantage. However, if the home downstream firm's costs are sufficiently higher than the foreign downstream firm's costs, the home country will levy the smallest import tariff on the intermediate goods, even if the home upstream firm has the highest costs. This leads to the following proposition.

Proposition 9.3 *Country i, with the most inefficient downstream firm (i.e., $c_i > c_j$), imposes the lowest import tariff on the final goods (i.e., $T_i < T_j$) if and only if $\frac{1}{2}(c_i - c_j) < k_j - k_i$. Further, country i, with the highest-cost upstream firm (i.e., $k_i > k_j$), imposes the lowest import tariff on the intermediate goods (i.e., $t_i < t_j$) if and only if $\frac{3}{4}(k_i - k_j) < c_i - c_j$.*

9.4 Conclusion

We have investigated the Nash equilibrium tariffs on final goods and intermediate goods imports in a model of vertically related markets characterized by Cournot competition. We show that, if the home upstream firm's costs are sufficiently lower than the foreign upstream firm's costs, the home country will impose the lowest import tariff on the final goods, even if the home downstream firm has the highest costs. Further, if the home downstream firm is significantly less efficient than the foreign downstream firm, the home country will levy the lowest import tariff on the intermediate goods, even if the home upstream firm has the highest costs.

Our model suggests some extensions. It would be interesting to consider product differentiation for the final goods and extend the analysis to Bertrand competition. Similarly, it would be important to consider the case of general numbers of downstream and upstream firms. We would like to extend our model to include these topics in future research.

Acknowledgements This work has been financially supported by a Grant-in-Aid for Scientific Research (B) (No. 25285079).

Appendix

Cournot Duopoly Model Without an Intermediate Goods Sector

Consider a Cournot duopoly model without an intermediate goods sector. The profits of home and foreign firms are given by $\pi_i = (p_i - c_i)\, y_{ii} + \left(p_j - c_i - T_j\right) y_{ji}$ $(i, j = 1, 2, i \neq j)$, where c_1 and c_2 are home and foreign firms' marginal costs, respectively. The welfare of each country is given by the sum of the firm's profits, consumer surplus, and tariff revenue: $W_i = \pi_i + CS_i + TR_i$ $(i = 1, 2)$, where $TR_i \equiv T_i y_{ij}$.

The equilibrium values in the Cournot duopoly case without a vertical industry structure are given by

$$y_{ii} = \frac{\alpha - 2c_i + c_j + T_i}{3},$$
$$y_{ij} = \frac{\alpha + c_i - 2c_j - 2T_i}{3},$$
$$Y_i = \frac{2\alpha - c_i - c_j - T_i}{3}, \quad i,j = 1,2, \quad i \neq j$$

When home and foreign governments simultaneously and independently choose their import tariffs to maximize national welfare, the Nash equilibrium import tariffs are

$$T_i = \frac{\alpha - c_j}{3}, \quad i,j = 1,2, \quad i \neq j$$

Comparing the Nash equilibrium import tariffs of the two countries yields

$$T_1 - T_2 = \frac{c_1 - c_2}{3}.$$

If the home firm has the highest costs, $c_1 > c_2$, then the home country will impose the highest tariff, $T_1 > T_2$. This leads to the following proposition.

Proposition A9.1 *The country with the highest-cost firm imposes the largest import tariff.*

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Part IV
Food and Trade Policies

Chapter 10
Strategic Trade Policy and Food Trade

Makoto Tawada and Madoka Okimoto

Abstract The increasing volume of food trade may result in unfavorable food inflows from foreign countries, where inspection costs are high or inspection quality is degraded. One solution is to charge food-trading companies for inspection costs. To this end, we create a model that delivers a game between the government of the food-importing country and foreign food firms. We then prove that, under a given unit inspection budget, the optimal tariff rate is one that balances inspection costs with tariff revenue. Under such a system, there is no market failure caused by the inflow of bad food, although this does not mean that inspection is not required for the food-importing country's efficiency. Thus, the condition of an optimal level of inspection is derived.

Keywords Food safety • Tariff • Inspection • Strategic trade policy

10.1 Introduction

In the age of globalization, the transportation system has become well developed, and free trade has become widespread. These recent changes in global society have particularly affected the food industry. Currently, people can consume all kinds of food that has been transported across long distances because preservation technology protects food quality, such that we can even enjoy fresh food that was produced in distant countries. There are specific characteristics of security, safety, and the natural environment associated with the trade of food. Regarding safety, an exporting country's government may not be concerned about the health of foreign people. Alternatively, the safety standards of food may differ among countries, thus allowing unfavorable food inflows from a foreign country. In contrast to other goods,

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*,
New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_10

it is usually difficult for consumers to distinguish between bad food and good food, which is vital given that food is directly related to the well-being of human beings.

Consumers are usually unable to determine what materials are used in processed food. A food production firm may try to reduce production costs by incorporating low-quality materials, which may be damaging to consumers' health. This incentive is likely strengthened when food is produced in a foreign country because it is difficult for the importing country's government to directly inspect foreign firms and punish them for supplying bad food. For example, Japan and China experienced such a conflict concerning toxic dumplings and, recently, as did China and Taiwan concerning tainted cooking oil.[1] It is well known that beef from cows infected with BSE had become a diplomatic issue among many countries. We should also notice that the scientific evidence about safety in production processes may matter. For instance, chlorinated chickens, hormone-treated beef, some chemical fertilizers, and GMOs have come into question regarding health and safety.

Hence, the government of a food-importing country must inspect the imported food. With economic globalization, either inspection costs are high or the inspection quality is degraded owing to the increasing volume of food trade. In fact, the US government has experienced a rapid increase in inspection costs and is facing difficulties keeping the inspection system of imported food sound. One solution to this difficulty is to charge inspection costs to food-trading companies. The Australian government charges all inspection costs to food importers based on the imported food control regulations of 1993. The Japanese system protects against inflows of bad food by imposing a certificate issued by government-designated authorities on high-risk food companies; those firms have to pay the cost of inspection to get the certificate.[2] Many trading companies complain about these policies. Thus, it is necessary to evaluate policies of this type from an economic point of view. In this chapter, we address food trade by focusing on this safety aspect, and we evaluate a food inspection policy where inspection costs are charged to the trading companies. It is revealed that the policy is reasonable in terms of the the importing country's economic efficiency.

Concerning trading with risk, there have been many studies on topics such as illegal migration and smuggling; however, studies on food trade regarding unhealthy food are sparse.[3] In the context of the food trade under asymmetric information, (Calzolari and Immordino, 2005) considered the case where food produced by an innovative technology causes health issues among consumers of that food. They assess the political decision of whether to ban or approve food produced using such production technologies. Cardebat and Cassagnard (2010) addressed the illegal

[1]The problem of the toxic dumplings occurred in January 2008. The tainted cooking oil problem occurred in September 2014.

[2]See the report of Mitsubishi Research Institute (2008) for the food inspection systems of the US and Australian governments. As for the Japanese food inspection system, see the Japanese Ministry of Health, Labour and Welfare (2014).

[3]See, for instance, Ethier (1986), Bond and Chen (1987), and Djajic (1997) on illegal migration and Bhagwati and Hansen (1973), Kemp (1976), and Martin and Panagariya (1984) on smuggling.

production processes of foreign firms under asymmetric information, so their model resembles our case, but the purpose is quite different. In addition, their model is more complicated because they introduce the possibility of a boycott of the illegal food and assume that imperfect competition prevails in the food industry. Because of this, the properties of the equilibrium are ambiguous, and the results are heavily dependent on the simulation analysis.

To investigate the abovementioned topic, we construct a model in which foreign firms are competing with domestic firms and reduce production costs by mixing in low-quality materials in the production process. The low-quality food may cause health issues for the consumers. Nevertheless, lower- income consumers may prefer the unhealthy food because of its low price. In our model, the importing government, from a national welfare point of view, wants domestic consumers to enjoy sound food. Thus, the importing government needs to inspect the imported food and ban bad food from being imported. Foreign firms, facing the possibility of illegal food detection, aim to maximize their profits by mixing lower-quality material into their products. Therefore, first, we consider a game between the welfare-maximizing home government and profit-maximizing foreign firms. In our game setting, we employ a special assumption that, under a given inspection cost, the home government will use a tariff policy to control the inflow of bad foreign food. Thus, the strategic variable of the home government is a tariff rate imposed on the foreign food, while that of the foreign firms is the mixed rate of bad food. In this game, we investigate the properties of each player's response function and the game equilibrium and make a comparative static analysis of the equilibrium.

In our setting, there is no market failure caused by the inflow of bad food since consumers have sufficient information on the inflow and influence of bad food, and all firms are perfectly competitive. However, the strategic behaviors of the food exporting firms and the food importing government cause positive levels of inspection and thus a tariff for the government to attain market efficiency.

This chapter is organized as follows. The next section introduces the model. Section 10.3 is devoted to the preliminary analysis. The properties of each player's response function for their game and the game equilibrium are investigated in Sect. 10.4. Section 10.5 is devoted to analysis of the optimal level of inspection for the food-importing country. The last section proposes our concluding remarks.

10.2 Model

Consider an economy consisting of a domestic country and a foreign country. Each country has profit-maximizing firms in food production. Although some studies, such as that of Cardebat and Cassagnard (2010), assume the existence of oligopolistic firms, it seems more realistic to suppose that many small firms are engaged in food production. Hence, it is assumed that all firms are perfectly competitive in both countries. We suppose that consumers exist only in the home country. Thus, all of the food produced in the foreign country is exported to the home country, and all of the food produced in the home country is domestically consumed. We call firms in home country H home firms and firms in foreign country F foreign firms.

Country H regulates food quality by adopting a certain quality standard and applies this standard to all food consumed in the country. We assume that home firms produce food under an identical constant marginal cost c^H and supply food satisfying the quality standard. In contrast, foreign firms produce food using a production process where they can reduce production costs by mixing in low-quality materials. If food is produced with such low-quality materials, it will not satisfy the quality standard adopted by the home country and will cause health issues to those who consume it. We assume that both types of food look the same superficially to consumers, so consumers cannot distinguish between safe and bad food. Consumers can, however, distinguish between foreign and domestic products based on their labels and have knowledge that some bad food is mixed in foreign food but not in the home food. Consumers are also aware of the health risks of consuming bad food.

We suppose that consumers are uniformly distributed in [0, 1] and each consumer will buy at most one unit of food. A consumer of type θ, where $\theta \in [0, 1]$, has disutility θ for the risk of consuming bad food. Now let us define α as the probability that a consumer chooses bad food when he/she buys the foreign food. All consumers have utility U for one unit of food. Therefore, defining p^H and p^F as the prices of home food and foreign food, respectively, the consumer surplus of type θ is exhibited as $CS^H(\theta) = U - p^H$ or $CS^F(\theta) = U - (1 + \theta)\alpha b - p^F$, respectively, according to the case where domestic food or foreign food is consumed. In the above formulation of $CS^F(\theta)$, b is defined as the disutility of consuming the bad food, such that αb and $\theta\alpha b$ imply the expected disutility of consuming bad food and the disutility against facing such a risk, respectively.

Each consumer will buy the food that brings forth the highest positive consumer surplus. Therefore, the condition for a consumer θ to buy home food is that $U - p^H \geq U - (1 + \theta)\alpha b - p^F$, or, equivalently, $\theta \geq (p^H - p^F - \alpha b)/\alpha b$ and $U - p^H \geq 0$. Likewise, the condition for a consumer θ to buy foreign food is that $U - p^H \leq U - (1+\theta)\alpha b - p^F$, or, equivalently, $\theta \leq (p^H - p^F - \alpha b)/\alpha b$ and $U - (1+\theta)\alpha b - p^F \geq 0$, or $(U - p^F - \alpha b)/\alpha b \geq \theta$.

Now, we consider the following assumption.

Assumption 10.1 $U - p^H > 0$ *and* $p^H - p^F - \alpha b > 0$.

Under this assumption, consumer θ will buy domestic food if $\theta \geq (p^H - p^F - \alpha b)/\alpha b$ and buy foreign food if $\theta \leq (p^H - p^F - \alpha b)/\alpha b$. This is illustrated in Fig. 10.1.

We turn our attention to the production side. All home country firms produce only sound food under the common constant marginal cost, c^H, whereas any foreign country firm has an incentive to produce bad food to reduce its production costs. Let the probability to produce bad food be β and the expected marginal cost be

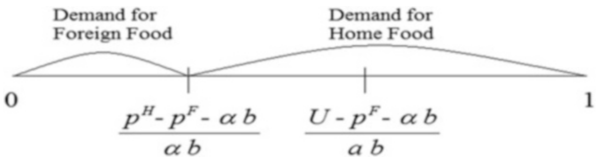

Fig. 10.1 Demands for home and foreign food

$c^F = c^F(\beta)$, where we assume $c^F_\beta \equiv dc^F/d\beta < 0$ and $c^F_{\beta\beta} \equiv d^2c^F/d\beta^2 > 0$.[4] The assumption that $c^F_{\beta\beta} > 0$ is necessary for the expected profit-maximizing foreign firms to determine the optimal probability to produce bad food.

We first consider the profit-maximizing behavior of a typical home firm, which is described as follows:

$$\max_{x^H} \pi^H = p^H x^H - c^H x^H, \tag{H}$$

under perfect competition, where x^H is the amount of food produced by the home firm.

Next, for a typical risk-neutral foreign firm, its expected profit-maximizing behavior is expressed as follows:

$$\max_{x^F,\beta} \pi^F = (1-\delta)\hat{p}^F x^F - c^F(\beta)x^F, \tag{F}$$

under perfect competition, where δ is the probability of bad food being detected when the firm produces it, $\hat{p}^F$ is the export price of the foreign food, and x^F is the amount of food produced by the foreign firm. In the above description of the profit-maximizing behavior, we suppose that the detected bad food has to be thrown away, but no fine is imposed because the home government cannot punish any foreign firms.

Our final step to describe our model is to explain the home government's behavior. The aim of the home country's government is to maximize the welfare of the home country when adopting policies. Here, we consider two policies: a tariff policy and an inspection policy. The home government imposes a tariff on the food imported from the foreign country. Let the tariff rate be t. The consumer price of the imported food is $\hat{p}^F + t \equiv p^F$. Concerning the inspection policy, the government uses an average cost g for the inspection of one unit of imported food. The bad food is necessarily detected if $g = \bar{g}$, but some bad food passes into the home market if $g < \bar{g}$. The government picks some samples randomly and examines them with the cost of $\bar{g}$ for one unit inspection. Suppose the government prepares the budget g for the average cost of one unit inspection. Then, the probability of detecting bad food

[4] Each firm decides whether it produces bad food according to the probability β.

from the foreign country is as follows:

$$\sigma = \frac{gX^F}{\bar{g}X^F} = \frac{g}{\bar{g}} \equiv \sigma(g),$$

where X^F is the total foreign food exported to the home country. Obviously, $\sigma'(g) = 1/\bar{g} > 0$ and $\sigma''(g) = 0$.

Denoting $T \equiv (p^H - p^F - \alpha b)/\alpha b$, we obtain the total demands of the home food and foreign food as $1 - T$ and T, respectively. Therefore, the social welfare of the domestic country is represented by the following:

$$SW = \int_T^1 (U - p^H)d\theta + \int_0^T [U - (1+\theta)\alpha b - p^F]d\theta - gX^F + tT, \tag{10.1}$$

where the first and second terms represent consumer surpluses accrued from the consumption of the home food and foreign food, respectively, gX^F is the cost of an inspection, and tT is the tariff revenue. The government tries to maximize (10.1) with respect to g and/or t.

10.3 Preliminary Analysis

Concerning the optimization problem (H), the zero-profit condition of the firm means the following:

$$p^H = c^H. \tag{10.2}$$

As for the foreign firms, the optimization problem (F) brings forth the following zero-profit condition:

$$(1-\delta)\hat{p}^F - c^F(\beta) = 0, \tag{10.3}$$

with the first-order condition for optimal β:

$$-\sigma\hat{p}^F - c^{F\prime}(\beta) = 0, \tag{10.4}$$

where the second-order condition, $-c^{F\prime\prime}(\beta) < 0$, is satisfied by assumption.

To inspect (10.1) in detail, we should notice that $\delta = \beta\sigma(g)$, $\alpha = \beta(1 - \sigma(g))/(1 - \beta\sigma(g))$, and $X^F = T/(1 - \beta\sigma(g))$. Moreover, $p^H = c^H$ and $p^F = \hat{p}^F + t = c^F(\beta)/(1 - \beta\sigma(g)) + t$, in view of (10.2) and (10.3). Hence, we obtain the following:

$$\begin{aligned} SW &= \int_T^1 (U - p^H)d\theta + \int_0^T [U - (1+\theta)\alpha b - p^F]d\theta - gX^F + tT \\ &= U - p^H + \int_0^T [p^H - (1+\theta)\alpha b - p^F]d\theta - gX^F + tT \\ &= U - p^H + \left[(p^H - p^F - \alpha b)\theta - \frac{1}{2}\alpha b\theta^2\right]_0^T - gX^F + tT \\ &= U - p^H + (p^H - p^F - \alpha b)T - \frac{1}{2}\alpha bT^2 - gX^F + tT \\ &= U - p^H + \alpha bT^2 - \frac{1}{2}\alpha bT^2 - gX^F + tT \\ &= U - p^H + \frac{1}{2\alpha b}(p^H - p^F - \alpha b)^2 - gX^F + tT. \end{aligned} \tag{10.5}$$

10.4 Game

We are now in a position to explain a game between the foreign firms and the home government. To maximize the welfare of the home country, the home government can use a tariff policy or an inspection policy. To simplify the analysis, we mainly focus on a situation where the home government uses the tariff policy to maximize the home national welfare under a given unit inspection budget.

Once the unit inspection budget g is given, the optimal condition of the tariff policy is obtained as

$$\begin{aligned} \frac{dSW}{dt} &= \frac{1}{\alpha b}\left(p^H - p^F - \alpha b\right)(-1) + \frac{1}{\alpha b}\left(p^H - p^F - \alpha b\right) + t\frac{dT}{dt} - g\frac{dX^F}{dt} \\ &= \frac{1}{\alpha b}\left(-t + \frac{g}{1 - \beta\sigma(g)}\right) = 0. \end{aligned} \tag{10.6}$$

In addition, the second-order condition is assured since $d^2SW/dt^2 = -1/\alpha b < 0$.

In what follows, we consider a noncooperative game in which foreign firms use the value of β and the home government uses the value of t as strategic variables. In this game, the foreign firms' reaction function is expressed by (10.4) and that of the home government is expressed by (10.6).

First, we investigate the properties of the reaction function of foreign firms. It is obvious by (10.4) that the optimal β for the firms has nothing to do with the level

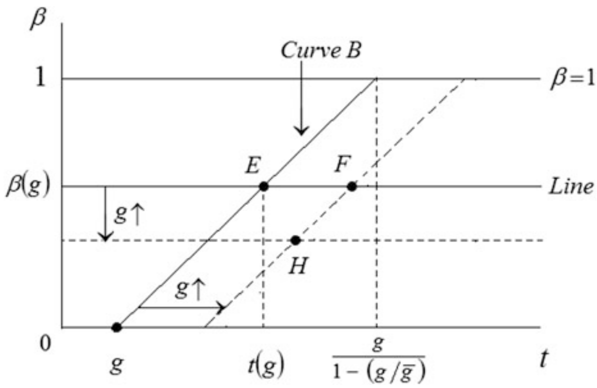

Fig. 10.2 Reaction curves and equilibrium

of the tariff rate t. Therefore, we can see in Fig. 10.2 that the reaction curve of the foreign firm becomes a horizontal line, like line A.

Total differentiation of (10.4) yields the following:

$$\frac{\sigma'(g)c^F(\beta)}{1-\beta\sigma(g)}\left(1+\frac{\beta\sigma(g)}{1-\beta\sigma(g)}\right)dg + \left\{\frac{\sigma(g)[c^{F\prime}(\beta)(1-\beta\sigma(g))+c^F(\beta)\sigma(g)]}{(1-\beta\sigma(g))^2}+c^{F\prime\prime}(\beta)\right\}d\beta=0,$$

from which we obtain

$$\frac{d\beta}{dg}=-\frac{\sigma'(g)c^F(\beta)\left(1+\frac{\beta\sigma(g)}{1-\beta\sigma(g)}\right)}{(1-\beta\sigma(g))c^{F\prime\prime}(\beta)}<0, \tag{10.7}$$

because $c^{F\prime}(\beta)(1-\beta\sigma(g))+c^F(\beta)\sigma(g)=0$ in view of (10.3) and (10.4). This implies that a rise in g reduces to a fall in β. The reaction curve, line A, thus shifts downward with an increase in g, as in Fig. 10.2.

Now we obtain the following:

Theorem 10.1

(i) Foreign firms determine their probability of producing bad food independently of the level of tariffs imposed by the home government.
(ii) When the domestic government adopts more severe inspection, foreign firms reduce their probability of producing bad food.

As for (i) of Theorem 10.1, the tariff affects only the amount of imported food through the demand for the foreign food. However, foreign firms produce food under perfect competition, so they do not care about the output level under technology with constant returns to scale. Thus, the probability β optimal to the firms has nothing to do with the level of the tariff. (ii) of Theorem 10.1 simply means that foreign firms decrease the probability β to control an increase in risk because the reinforcement of the inspection increases the risk of bad food being detected.

Next, we will investigate the reaction function of the home government expressed by (10.6). Under the assumption that $\beta > 0$ and $g > 0$, the tariff t satisfying (10.6) is positive because

$$t = \frac{g}{1 - \beta\sigma(g)} > 0. \tag{10.8}$$

With the above equation, we also obtain the following:

$$\frac{\partial t}{\partial \beta} = \frac{g\sigma\,(g)}{(1 - \beta\sigma(g))^2} > 0$$

and

$$\frac{\partial t}{\partial g} = \frac{1 - \beta\sigma(g) + \beta\sigma'(g)}{(1 - \beta\sigma(g))^2} > 0.$$

Finally (10.6) yields

$$tT - gX^F = \left[t - \frac{g}{1 - \beta\sigma(g)}\right] T = 0,$$

implying that the optimal reaction for the home government is to balance the tariff revenue and the total cost of inspection.

Now, we can summarize the properties of the optimal reaction of the home government as follows:

Theorem 10.2 *Concerning the tariff reaction of the home government,*

(i) For any given $\beta > 0$ and $g > 0$, the tariff rate is positive.
(ii) The tariff reaction against β is such that the tariff revenue is balanced with the inspection cost; thus, the tariff rate is zero if there is no inspection.
(iii) A rise in the probability for the foreign firms to produce bad food raises the tariff rate.
(iv) An increase in the budget for inspection raises the tariff rate.

Among the results in Theorem 10.2, the most interesting and important is (ii), which can be interpreted as follows: If the tariff revenue is more than the total inspection cost, the economy becomes inefficient owing to the trade barrier of the too heavy tariff. Conversely, if the tariff revenue is less than the total inspection cost, the inspection is too costly. Under the given inspection cost, therefore, the government's best tariff strategy is to cover the inspection cost with the tariff revenue. The tariff policy is equivalent to a certification policy where the government inspection cost is charged to the exporting firms. Hence, some governments, such as the

Australian and Japanese governments, adopt a certification policy because the direct application of a tariff policy becomes difficult under the global movement of free trade.

(i) is a natural conclusion from (ii). The reason for (iii) is that a rise in the probability β by the foreign firms increases the home consumers' risk to consume bad food; hence, the home government tries to reduce this risk with a rise in tariffs to discourage foreign firms from exporting such food. (iv) simply means that an increase in the expenditures for inspection should be covered by the tariff revenue as stated in (ii). The level of the tariff rate thus increases. Because of (iii) and (iv), the home government's reaction curve slopes negatively, which is illustrated as curve B in Fig. 10.2, and shifts to the right with an increase in g.

We can now see an equilibrium of the game between foreign firms and the home government. The equilibrium of the game is characterized by two equations, (10.4) and (10.6), which determine β and t under $g \geq 0$. Therefore, we express these equilibrium β and t by $\beta(g)$ and $t(g)$, respectively. In Fig. 10.2, the equilibrium pair of $\beta(g)$ and $t(g)$ is displayed by point E. Once g becomes larger, the reaction curves A and B move downward and to the right, respectively. Hence, equilibrium point E moves to point H, where the new reaction curves are intersecting. It is easy to see from this illustration that an increase in g decreases $\beta(g)$, but whether $t(g)$ rises or falls is ambiguous.

To investigate the movement of $t(g)$ in greater detail, we calculate dt/dg. We obtain the following:

$$\begin{aligned} dt &= \left.\frac{\partial t}{\partial g}\right|_{(10.6)} dg + \left.\frac{\partial t}{\partial \beta}\right|_{(10.6)} \left.\frac{d\beta}{dg}\right|_{(10.4)} dg \\ &= -\frac{g\sigma(g)}{(1-\beta\sigma(g))^2}\frac{c^F(\beta)\,\sigma'(g)\left(1+\frac{\beta\sigma(g)}{1-\beta\sigma(g)}\right)}{(1-\beta\sigma(g))c^{F\prime\prime}(\beta)} + \frac{1-\beta\sigma(g)+\beta\sigma'(g)}{(1-\beta\sigma(g))^2}, \end{aligned} \tag{10.9}$$

where $[\partial t/\partial g]_{(10.6)}$ is the partial derivative of (10.6), for example. The first and second terms on the right-hand side of (10.9) show the indirect and direct effects, respectively. In Fig. 10.2, the direct effect is expressed by a shift in t from E to F, whereas the indirect effect is a shift in t from F to H. The direct effect implies that, for an increase in g, the home government raises t to cover an increase in the inspection cost. In contrast, the indirect effect means that, with an increase in g, foreign firms lower β, and the home government reacts to this lowering of β with the reduction of t. The direct effect is positive, whereas the indirect effect is negative. Hence, $dt/dg > (<)0$, if and only if the direct effect is greater (less) than the indirect effect.

We also see that the degree of consumer disutility caused by consuming bad food has nothing to do with the full equilibrium. This is because neither Eq. (10.4) nor Eq. (10.6) contains b. The reason for this result is that b can affect only the food supply of foreign firms through the demand for the foreign food, but β is determined independently of the foreign production level. Moreover, b can affect the tariff revenue of the home government through the demand for foreign food, but it cannot be influential to t because of the optimal condition that the tariff revenue has to be balanced with the total inspection cost, that is, $tT - gX^F = [t - g/(1 - \beta\sigma(g))]\,T = 0$.

The following theorem is a summary of the above results concerning the full equilibrium.

Theorem 10.3 *For any given positive g, there is a unique positive equilibrium pair of β and t. For a greater g, the equilibrium value of β is smaller and that of t is larger (smaller) if the direct (indirect) effect of g to t overwhelms that of the indirect (direct) effect. Finally, the equilibrium values of β and t are never affected by the degree of consumer disutility caused by consuming bad food.*

Proof It is sufficient to show that there is a unique positive equilibrium pair of β and t for any given positive g, since the remaining part of the theorem has been shown already. By the property of our model, we can confine the range of g to $[0, \bar{g}]$. As for the reaction line of the foreign firms, if $g = 0$, $\beta = 1$, and if $g = \bar{g}$, $\beta = 0$. (The details of the derivation are omitted.) Moreover, β decreases as g increases. Thus, in Fig. 10.2, the reaction line A must be a horizontal line with $\beta \in (0, 1)$ for any $g \in (0, \bar{g})$. Concerning the reaction curve of the home government, let $t = g/(1 - \beta(g/\bar{g})) \equiv f(\beta, g)$. Then, for any given $g \in (0, \bar{g})$, we have

$$\lim_{\beta \to 0} f(\beta, g) = g \quad \text{and} \quad \lim_{\beta \to 1} f(\beta, g) = \frac{g}{1 - (g/\bar{g})} > g.$$

Hence, the home government's reaction curve, curve B in Fig. 10.2, necessarily cuts the foreign firms' reaction line, line A. Moreover, as seen in the figure, this cutting point is an equilibrium point $(t(g), \beta(g))$ and satisfies $t(g) > 0$ and $0 < \beta(g) < 1$. *Q.E.D.*

10.5 Optimal Inspection

Once β is given, the optimal inspection is no inspection since there is no market failure in the home country. In our circumstances, however, the best strategy of the foreign firms is to set $\beta = 1$ if the home government executes no inspection. Then the home welfare may increase if the home government introduces inspection in order to make the foreign firms reduce the level of β. Thus, we need to seek the optimal inspection level for the home country.

In order to determine the optimal inspection level, the home government sets the welfare maximization problem as

$$\max_{g} \; SW = \int_T^1 \left(U - p^H\right) d\theta + \int_0^T \left[U - (1 + \theta)\alpha b - p^F\right] d\theta - gX^F + tT,$$

$$\text{subject to} \quad t = \frac{g}{1 - \beta\sigma(g)}, \qquad (10.8)$$

$$(1-\delta)\hat{p}^F - c^F(\beta) = 0, \tag{10.3}$$

$$-\sigma\hat{p}^F - c^{F\prime}(\beta) = 0, \tag{10.4}$$

which can be reduced to

$$\max_g \quad U - p^H + \frac{1}{2\alpha b}\left(p^H - p^F - \alpha b\right)^2,$$

$$\text{subject to } \frac{\sigma(g)c^F(\beta)}{1-\beta\sigma(g)} = -c^{F\prime}(\beta).$$

After tedious calculation, we have the first-order optimum condition such that

$$\frac{2(1-\beta\sigma(g))\left[\bar{g} + c^F(\beta)\beta - \beta b(1-\beta)\right]}{1-\sigma(g)} - (1-\beta)\alpha bT = \frac{c^F(\beta)\left[2\left(b + \frac{\sigma(g)}{1-\sigma(g)}g\right) + bT\right]}{c^{F\prime\prime}(\beta)(1-\beta\sigma(g))}.$$

(The details of the derivation are omitted. Any reader can request them from one of the authors if necessary.)

Because of this lengthy equation, it is hard to develop the analysis further without functional specification and numerical simulation.

10.6 Concluding Remarks

In this chapter, we investigated an optimal tariff on foreign food, which may be harmful to consumers' health. The framework we employed is a game between the importing country's government and the exporting countries' firms. The strategic variables of the government and the firms are an import tariff to control the import amount and a mixed rate of bad food to reduce production costs, respectively.

We showed that, under a given unit inspection budget, the optimal tariff rate is the one that balances the total inspection cost with the tariff revenue. Thus, no tariff is the optimal strategy for the importing government if there is no inspection of the imported food. We also showed that, for a greater unit inspection budget, foreign firms' mixed rate of bad food was lower, and the tariff rate imposed on the foreign food by the government was higher (lower) if the direct (indirect) effect of a change in the unit inspection budget to the tariff on foreign food overwhelmed the indirect (direct) effect. We also revealed that the equilibrium values of the mixed rate of bad food and the tariff rate on foreign food were never affected by the degree of consumer disutility caused by having bad food. Finally, we derived the optimal condition of the inspection level for home welfare maximization.

We considered the case where, under a given level of inspection cost, the home government determines the optimal tariff rate corresponding to a given rate of mixing bad food. Alternatively, we can suppose the case where, under a given tariff rate, the government determines the optimal inspection cost against a given rate of mixing bad food. In both cases, however, the relationship between the optimal tariff rate and inspection cost is the same since it is expressed by the balanced budget equation (10.8). Therefore, regardless of the case we consider, we reach the same results.

Although we selected the tariff policy in order to finance the inspection cost, there is another way to finance the inspection cost, which is to use a fine levying policy where a fine is imposed on detected bad food. Even in this case, a similar result carries over. That is, for any given inspection cost and rate of mixing bad food, the optimal fine level is such that the total fine revenue equals the total inspection cost. A detailed analysis of this case is explored by Okimoto and Tawada (2016).

Acknowledgements We thank Professor Makoto Okamura for a perceptive comment following which this chapter was greatly improved. We are also grateful to Professor Binh Tran-nam and the participants of the seminars at Hoa Sen University in Ho Chi Minh City and at the University of Asia and the Pacific in Manila. Madoka Okimoto gratefully acknowledges the financial support of a grant-in-aid for the basic research (A) #21243023 and for JSPS Fellows #23-3981 from the Japan Society for the Promotion of Science (JSPS), respectively.

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Chapter 11
International Price Competition Among Food Industries: The Role of Income, Population, and Biased Consumer Preference

Madoka Okimoto

Abstract Sensitivity to prices among poor citizens means that a hike in food prices, as a burden on consumers, hinders the adequate supply of inexpensive food and worsens food safety problems caused by low-priced food. This chapter theoretically studies the impact of economic growth with demographic transitions and food safety on food prices, providing a background for policies to protect consumers. The results imply that the sources of food price hikes are (a) *economic growth*, (b) *population growth accompanied by an expansion in the income gap*, (c) *remarkable population growth in the past*, and (d) *deterioration in the safety of foods made in the South*. In the North, (d) is the most important factor; additionally, (a) and (b) in the South would affect global food prices, while food price hikes are inseparable from economic advancement in the South. Accordingly, guaranteeing the food safety of Southern foods leads to stable food prices in the North, whereas as long as economic advancement in the South continues, encouraging policies that artificially promote stable food prices and ensure food safety will be needed for both developing and developed countries.

Keywords Food security • Food price hike • Price competition • Income distribution • Population growth • Bounded rationality

11.1 Introduction

Since 2006, the international price of grain has clearly been trending higher compared with the period between 1970 and 2006.[1] What causes international food prices to become higher and unstable? Academic research exploring the source

[1] See "Ministry of Agriculture, Forestry and Fisheries," http://www.maff.go.jp/e/index.html

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T. Ohkawa et al. (eds.), *Regional Free Trade Areas and Strategic Trade Policies*, New Frontiers in Regional Science: Asian Perspectives 10,
DOI 10.1007/978-4-431-55621-3_11

of food price hikes has begun in earnest because of this change. Baek and Koo (2014) empirically found that the exchange rate is a significant factor influencing US food prices. Yu (2014) also empirically found that food prices tend to decline in response to monetary expansion in China. The source of this type of a price hike has been considered to be, for example, abnormal weather conditions caused by environmental pollution in food-exporting countries, a sudden rise in energy prices, and rapid growth in the global population.

To examine food price hikes from a slightly different angle, it is worth analyzing how the recent global population movements and the expansion of the income gap that come with economic advancement have affected food prices. In 2011, the United Nations Population Fund forecast that by the end of the century, the world population would exceed 100 billion and that the African population would increase threefold to approximately 36 billion, while the Asian population would continue to increase until 2050 and thereafter decrease.[2] In various countries, the rise in the population of those in poverty has also become a serious problem in recent decades. Hence, taking account of theories related to demographic transition that express how economic growth influences the population, such as those promulgated by Stolnity (1964), Leibenstein (1974), and Becker (1960), we develop demand functions affected by changes in the social structure and incorporate those changes in an international Bertrand competition model for food industries, with the goal of capturing the price determination.

In a transitioning economy, the key issue is that soaring food prices force the poor to select low-priced food, e.g., food made in the South (developing countries), although Southern food may be questionable with respect to safety. Food price hikes are likely to hinder the adequate supply of low-priced food that nourishes the poor together with possible health hazards. Hence, our model considers a food firm located in the North and a food firm located in the South and describes the market of a country where both risky food made in the South and safe food made in the North are provided. On this point, the most closely related research is that of Cardebat and Cassagnard (2010), who assumed Bertrand competition between the Northern and Southern firms and asymmetric information about the production process in the South and analyzed the exclusion of problematic Southern goods by the Northern government. In Cardebat and Cassagnard (2010), however, Southern goods did not represent a possible health hazard. Calzolari and Immordino (2005) also investigated international trade in innovative food subject to uncertain health effects and described governments' decisions related to food safety through a learning process with its solution concept, the perfect Bayesian equilibrium. However, we owe the simple explanation of the food price hike under some risks to Nash equilibrium, as our model is not defined to analyze governments' decisions. Becchetti et al. (2014) theoretically investigated the conditions under which a firm switches from price competition to price and CSR (corporate social responsibility) competition, e.g., in the market for organic food. Thus, the Becchetti et al. (2014)

[2] "See United Nations Population Fund (2011)."

model has many points of resemblance to our model but retains an interest in corporate behavior.

What makes the problem of food safety more serious is consumer behavior. In our model, consumers are distributed based on income, and lower-income individuals are less sensitive to health damage. Examining the effect of income on behavior in the context of choosing differently priced healthcare plans by low-income families, Chan and Gruber (2010) empirically insisted that higher-income individuals were not more price sensitive and that those who selected the lowest-cost plan were more price sensitive. Although Cawley and Ruhm (2011) provided an overview of risky health behavior and showed that income could either increase or decrease unhealthy behaviors, how income affects behavior should depend on the situation, and our setting in which income promotes health consciousness is considered as more appropriate.[3] Among the vigorous discussion on bounded rationality, e.g., Herbert (1984), Gruber and Köszegi (2001), and many others, it is also important to note that McDermott et al. (2008) suggested that people could be harmed by their inherent preferences for certain foods, which would prove the existence of factors that divert our attention from food safety.

In Sect. 11.2, we define our model of income and population. In Sect. 11.3, we determine the demand functions and a game between food industries, completing and closing the model. With the full model in hand, Sect. 11.4 analyzes the nature of food prices. Section 11.5 presents the conclusions, while the Appendix A through C report detailed calculation processes.

11.2 Model of Population Changes, Food Prices, and Food Safety

We consider the world economy composed of the North and South. Because income level and health awareness differ from person to person, it is natural to imagine that food product choices are differentiated and tailored. Hence, in the model, a representative Northern firm (N-firm) in the North produces Northern food (N-food), and a representative Southern firm (S-firm) in the South produces Southern food (S-food). Both types of food are provided for the world market and appear easily distinguishable from each other. The problem we set is that the consumption of S-food may cause health damage, but there is a demand for S-food because its price is sufficiently low. Hence, we discuss at what levels the prices of these two types of food are determined in the food market according to how consumers react to health damages. First, we define the basic quality of food common to both types

[3] Using 2008 data based on population subgroups stratified by family income, race, and so on from the National Health Interview Survey (NHIS), Cawley and Ruhm (2011) showed empirical evidence of the existence of disparities in health behaviors across subgroups.

of food and the extent of health damage as q and D, which are to be given and constant.

11.2.1 Consumers and Health Awareness

Let us consider two levels of utility for consumers that depend on q, D and each consumer's personal income level. Namely, the utility obtained from one unit of food is expressed as

$$U(q, D; I_i) = U^1(q) + U^2(D; I_i) = \sqrt{q} + (-I_i) D$$
$$= \begin{cases} \sqrt{q} & \text{for safe food} \\ -I_i D & \text{for unsafe food} \end{cases}$$

for the whole consumer. Here, I_i denotes the personal income level of consumer i, and we suppose that all the N-food and $(1 - m)$ percent of S-food are safe food with $q > 0$ and $D = 0$, while m percent of S-food is unsafe food with $D > 0$ and $q = 0$. As the comprehensive utility, $U(q, D; I_i)$, is measured by both $U^1(q)$ and $U^2(D; I_i)$, the concavity of $U^1(q) = \sqrt{q}$ implies that each consumer is risk averse, and $U^2(D; I_i) = (-I_i) D$ expresses health awareness, which depends on personal income level and diminishes in proportion to the extent of an individual's poverty. That is, this formula of utility is based on the cardinal behavior for food consumption: (i) when the value of health damage, D, is positive, the basic quality, q, no longer makes sense; (ii) behavior related to food consumption is risk averse; and (iii) lower-income individuals are less sensitive to health damage.

For consumer i with I_i, the difference between the utility and the price of the corresponding food gives two consumer surpluses:

$$CS^N = \sqrt{q} - p^N, \tag{11.1}$$

$$CS_i^S = (1 - m)\sqrt{q} - mI_i D - p^S. \tag{11.2}$$

Here, p^j ($j = N, S$) denotes the price of j-food. Comparing two levels of consumer surplus, consumer i chooses N-food or S-food and demands at most one j-food ($j = N, S$). Next, we suppose that consumer i has an incentive to purchase a food if the consumer obtains a nonnegative consumer surplus by purchasing that food:

$$CS^N \geq 0 \Leftrightarrow \sqrt{q} - p^N \geq 0, \tag{11.3}$$

$$CS_i^S \geq 0 \Leftrightarrow \frac{(1 - m)\sqrt{q} - p^S}{mD} \geq I_i. \tag{11.4}$$

We also suppose that consumer *i* prefers and chooses the type of food that gives the consumer a higher consumer surplus. Accordingly, the income level of marginal consumers is expressed as

$$CS^N = CS_i^S \Leftrightarrow I_i = \frac{p^N - p^S - m\sqrt{q}}{mD}. \tag{11.5}$$

As for Eqs. (11.3)–(11.4), we note that both types of food are provided only after $\sqrt{q} \geq p^N$ and $\sqrt{q} \geq p^S$ are ensured. In addition, if $p^N \leq p^S$ holds, not only would $CS^N > CS_i^S$ hold for the entire consumer, but also, with regard to Eq. (11.5), $\frac{p^N - p^S - m\sqrt{q}}{mD}$ would be negative. Thus, to focus on the circumstance that both types of food are provided, we set

Condition 11.1 $\sqrt{q} \geq p^N > p^S$.

Under Condition 11.1, all consumers can obtain a consumer surplus from N-food, while only the poor can obtain a consumer surplus from S-food. Last, $\frac{(1-m)\sqrt{q} - p^S}{mD} - \frac{p^N - p^S - m\sqrt{q}}{mD} = \frac{\sqrt{q} - p^N}{mD} > 0$ concludes that the income level where the incentive to purchase S-food vanishes is above the marginal income indicated by Eq. (11.5) as in Fig. 11.1. Consequently, we define the threshold of the demand as $I^{TD} \equiv \frac{p^N - p^S - m\sqrt{q}}{mD}$.

11.2.2 *Link Between Population Growth and Income*

For a country, we suppose that μ denotes the income level of the country and g denotes the income gap of the country so that $\mu - \frac{g}{2}$ represents the bottom income and $\mu + \frac{g}{2}$ represents the highest income. We also assume that consumers in the country are distributed continuously according to the level of I_i over $\left[\mu - \frac{g}{2},\ \mu + \frac{g}{2}\right]$ where $\mu - \frac{g}{2} \geq 0$ and $\mu + \frac{g}{2} > 0$. While μ and g are largely

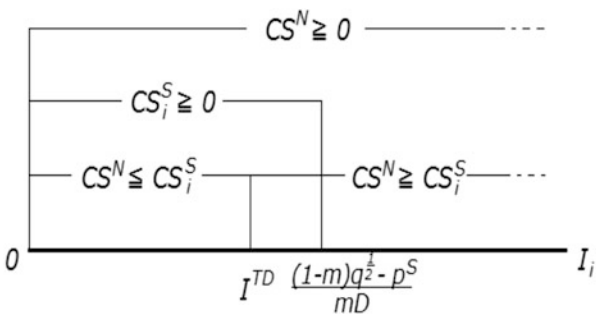

Fig. 11.1 Threshold of demand over the personal income level

determined by industrial development and cyclical economic changes, we consider μ and g as given for simplicity.

In addition, as in Stolnity (1964), Leibenstein (1974), and Becker (1960), at the outset of economic growth, a general rise in μ causes the rate of population growth to increase, after which the rate of increase begins to fall at the maturation period of economic growth. This is based on the fact that as a rule of thumb, the higher μ grows, the lower the birth rate gradually becomes and the lower the death rate drastically becomes. Accordingly, a country's population will tend to rise in most of the South's developing countries, while many advanced economies are faced with a reduction in the population. Taking the above, we develop a function that characterizes the population in each level of I_i as

$$L(I_i) = \begin{cases} xI_i & \text{if } 0 \leq I_i \leq I^T \\ \bar{L} - yI_i & \text{if } I^T \leq I_i, \end{cases} \tag{11.6}$$

where $x > 0$ and $y > 0$. Because we disregard other factors that may affect the population, $L(0) = 0$ holds. Note that $\bar{L}$ is not the highest income level. Hence, according to the given μ, g, and $L(I_i)$, the total population of the country is determined by $TL(\mu, g) = \int_{\mu-\frac{g}{2}}^{\mu+\frac{g}{2}} L(I_i)\, dI_i$.

Here we suppose that if $\mu - \frac{g}{2} < I^{TD} < \mu + \frac{g}{2} \leq I^T$ holds, the country is a Southern developing country, whereas if $I^T \leq \mu - \frac{g}{2} < I^{TD} < \mu + \frac{g}{2}$ holds, the country is a Northern developed country. Hence, as in Fig. 11.2, $TL(\mu, g)$ in the South and North is expressed as

$$TL^{South}(\mu, g) = \int_{\mu-\frac{g}{2}}^{\mu+\frac{g}{2}} (xI_i)\, dI_i = \left[\frac{1}{2}xI_i^2\right]_{\mu-\frac{g}{2}}^{\mu+\frac{g}{2}} = x\mu g,$$

$$TL^{North}(\mu, g) = \int_{\mu-\frac{g}{2}}^{\mu+\frac{g}{2}} \left(\bar{L} - yI_i\right) dI_i = \left[\bar{L}I_i - \frac{1}{2}yI_i^2\right]_{\mu-\frac{g}{2}}^{\mu+\frac{g}{2}} = \left(\bar{L} - y\mu\right) g.$$

Note that $\frac{\partial TL^S(\mu,g)}{\partial \mu} > 0$ and $\frac{\partial TL^N(\mu,g)}{\partial \mu} < 0$ means that economic growth in a Southern (Northern) country makes the total population increase (decrease), while in $\frac{\partial TL^j(\mu,g)}{\partial g} > 0$ $(j = N, S)$ a rise in g indicates population growth with an expansion of the income gap.

11.3 Timing of Game

To clearly analyze the equilibrium food price, we assume Bertrand competition among N-firm and S-firm in the food market in one country where both types of food are provided as in Fig. 11.3. In the model, said country may be one of two types: (i) a developed country in the North or (ii) a developing country in the South.

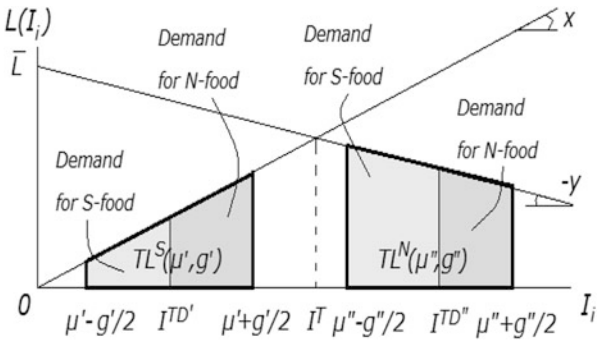

Fig. 11.2 Population growth and income (Note: Even if the foods provided in the North are identical to those provided in the South, stronger food safety standards can reduce the ultimate level of m and D in the North and cause I^{TD} in the North to be above I^{TD} in the South)

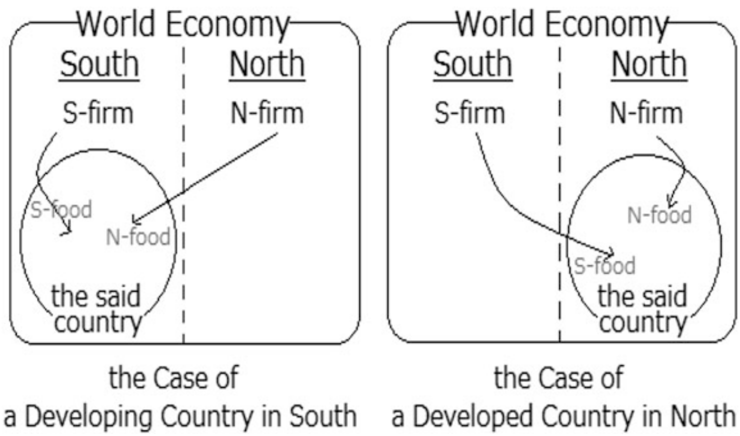

Fig. 11.3 Intestine food market

The reason we distinguish among two types of countries is that the demand in the South differs from that in the North.

11.3.1 *Demands and Producers in the Case of a Developed Country in the North*

Because we have already modeled how consumers are distributed and the location of the threshold, the demand functions of j-food ($j = N, S$) in a Northern country are expressed as follows:

$$\begin{aligned} x^N &= \int_{I^{TD}}^{\mu+\frac{g}{2}} \left(\bar{L} - yI_i\right) dI_i \\ &= \bar{L}\left(\mu + \frac{g}{2}\right) - \frac{1}{2}y\left(\mu + \frac{g}{2}\right)^2 \\ &\quad - \left[\bar{L}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \frac{1}{2}y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2\right], \end{aligned} \tag{11.7}$$

$$\begin{aligned} x^S &= \int_{\mu-\frac{g}{2}}^{I^{TD}} \left(\bar{L} - yI_i\right) dI_i \\ &= \bar{L}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \frac{1}{2}y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 \\ &\quad - \left[\bar{L}\left(\mu - \frac{g}{2}\right) - \frac{1}{2}y\left(\mu - \frac{g}{2}\right)^2\right]. \end{aligned} \tag{11.8}$$

Here, x^j $(j = N, S)$ denotes the demand for j-food $(j = N, S)$. Hence, the decision-making actions of N-firm and S-firm under Bertrand competition are displayed as

$$\max_{p^N} \pi^N = \left(p^N - c^N\right) x^N,$$

$$\max_{p^S} \pi^S = \left(p^S - c^S\right) x^S,$$

where x^N and x^S are characterized by Eqs. (11.7)–(11.8) and c^j $(j = N, S)$ expresses the unit cost for the food production of j-firm $(j = N, S)$. Then, we obtain $F.o.c.$s as

$$\begin{aligned} &\bar{L}\left(\mu + \frac{g}{2}\right) - \frac{1}{2}y\left(\mu + \frac{g}{2}\right)^2 - \left[\bar{L}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \frac{1}{2}y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2\right] \\ &+ \frac{\left(p^N - c^N\right)}{mD}\left[-\bar{L} + y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] = 0, \end{aligned} \tag{11.9}$$

$$\begin{aligned} &\bar{L}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \frac{1}{2}y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \left[\bar{L}\left(\mu - \frac{g}{2}\right) - \frac{1}{2}y\left(\mu - \frac{g}{2}\right)^2\right] \\ &- \frac{\left(p^S - c^S\right)}{mD}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] = 0. \end{aligned} \tag{11.10}$$

In this argument, we set the condition that guarantees $S.o.c.$ of N-firm as

Condition 11.2 $\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - y\left(\frac{p^N - c^N}{mD}\right) > 0.$

Hence, we obtain $\frac{d^2\pi^N}{dp^{N2}} = -\frac{1}{mD}\left\{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\left(\frac{p^N - c^N}{mD}\right)\right\} < 0.$ Likewise $\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) = \bar{L} - yI^{TD} > 0$, which should hold to construct a plausible analysis, demonstrates $\frac{d^2\pi^S}{dp^{S2}} < 0$. Additionally, the slopes of the reaction functions for j-firm ($j = N, S$), or $\left.\frac{dp^N}{dp^S}\right|_N = \frac{\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - y\left(\frac{p^N - c^N}{mD}\right)}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\left(\frac{p^N - c^N}{mD}\right)} > 0$ and $\left.\frac{dp^N}{dp^S}\right|_S = \frac{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\left(\frac{p^S - c^S}{mD}\right)}{\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) + y\left(\frac{p^S - c^S}{mD}\right)} > 0$ provide the strategic complementary relationship so that the stability condition, $\left.\frac{dp^N}{dp^S}\right|_S > \left.\frac{dp^N}{dp^S}\right|_N > 0$, is satisfied (See Appendix A.).

11.3.2 Demands and Producers in the Case of a Developing Country in the South

The demand functions of j-food ($j = N, S$) in a Southern country are expressed as follows:

$$X^N = \int_{I^{TD}}^{\mu + \frac{g}{2}} (xI_i)\, dI_i = \frac{1}{2}x\left(\mu + \frac{g}{2}\right)^2 - \frac{1}{2}x\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2, \qquad (11.11)$$

$$X^S = \int_{\mu - \frac{g}{2}}^{I^{TD}} (xI_i)\, dI_i = \frac{1}{2}x\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \frac{1}{2}x\left(\mu - \frac{g}{2}\right)^2. \qquad (11.12)$$

Here, X^j ($j = N, S$) denotes the demand for j-food ($j = N, S$). The decision-making of N-firm and S-firm is also displayed as

$$\max_{P^N} \pi^N = \left(P^N - c^N\right) X^N,$$

$$\max_{P^S} \pi^S = \left(P^S - c^S\right) X^S,$$

where X^N and X^S are characterized by Eqs. (11.11)–(11.12) and c^j ($j = N, S$) expresses the unit cost of j-firm's food production ($j = N, S$). To distinguish the price in the South versus the North, we capitalize the price in the case of the South as P^j ($j = N, S$). Subsequently, we have $F.o.c.$s, the reaction functions of N-firm and S-firm from the top, as

$$\frac{1}{2}\left(\mu+\frac{g}{2}\right)^2-\frac{1}{2}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(P^N-c^N\right)}{mD}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)=0, \tag{11.13}$$

$$\frac{1}{2}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)^2-\frac{1}{2}\left(\mu-\frac{g}{2}\right)^2-\frac{\left(P^S-c^S\right)}{mD}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)=0. \tag{11.14}$$

Here, we utilize the reduced form of Eq. (11.14), which provides $\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}=\left(\mu-\frac{g}{2}\right)^2\left(\frac{mD}{P^N-P^S-m\sqrt{q}}\right)+\frac{\left(P^S-c^S\right)}{mD}>0$; the second-order conditions are calculated as $\frac{d^2\pi^N}{dP^{N2}}<0$ and $\frac{d^2\pi^S}{dP^{S2}}=-\frac{x}{mD}\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]<0$. Additionally, the slopes of Eqs. (11.13) and (11.14), $\left.\frac{dP^N}{dP^S}\right|_N=\frac{\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\left(\frac{P^N-c^N}{mD}\right)}{2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\left(\frac{P^N-c^N}{mD}\right)}>0$ and $\left.\frac{dP^N}{dP^S}\right|_S=\frac{2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\left(\frac{P^S-c^S}{mD}\right)}{\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\left(\frac{P^S-c^S}{mD}\right)}>0$, show that the stability condition, $\left.\frac{dP^N}{dP^S}\right|_S>\left.\frac{dP^N}{dP^S}\right|_N>0$, is satisfied (see Appendix A.).

11.4 Comparative Statics

As shown in Fig. 11.4, the equilibrium prices in a Northern country are characterized by Eqs. (11.9)–(11.10) and denoted by p^{j*} $(j=N,S)$ from this point forward. Likewise, for a Southern country, the prices at the equilibrium are characterized by Eqs. (11.13)–(11.14) and denoted by P^{j*} $(j=N,S)$ from this point forward (see Appendix B for the calculation process of the comparative statics, and see Appendix C for the derivation of the natures of reaction functions).

11.4.1 Population Movement

In the model, the higher level of x (of y) corresponds to the higher growth rate (the more serious negative growth rate) of the population, and the higher level of $\bar{L}$ denotes the later timing at which the population takes a downward turn. Because the results with respect to $\bar{L}$ and y are $\frac{dp^{j*}}{d\bar{L}}>(<)\,0$ and $\frac{dp^{j*}}{dy}<(>)\,0$ $(j=N,S)$, if the values of g, c^N, and c^S are sufficiently high (low), and the result with respect to x is $\frac{dP^{j*}}{dx}=0$ $(j=N,S)$, we reach

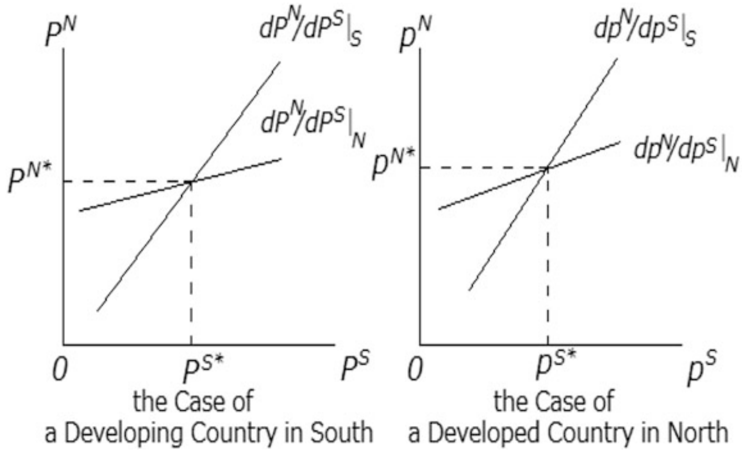

Fig. 11.4 Bertrand equilibrium prices

Theorem 11.1 *I) The population growth rate in a Southern country is not related to food prices. II) In a Northern country, if the country's income gap and the production costs for a Northern and Southern firm are large and high, (i) as the time when the population reaches the turning point grows later, the price of Northern and Southern food rises, and (ii) as the negative growth rate of the population accelerates, the price of Northern and Southern food falls.*

First, (I) is obtained because there is no direct effect on the price, and firms do not heed the population growth rate in the South. Comparing the demand functions in the Northern case with those of the Southern case, we find that after the economy experiences a transformation in the properties of population growth, the population growth rate begins to influence the food price. This implies that historical changes in population and demand affect the current level of demand and that the growth rate does not affect food prices in the South because the South's population has not reached the population peak.

As to (II), the direct effects are obtained as $\frac{dp^j}{d\bar{L}} > 0$ and $\frac{dp^j}{dy} < 0$ $(j = N, S)$, if the values of g, c^N, and c^S are high and have a decisive influence on the result. Although the plausible result concerning a Northern country stated in (II) can be reversed by a smaller income gap and operating at lower costs, which implies lower prices, the reversed result is counterintuitive and can be an exception corresponding to prices that are too low. Accordingly, (II) implies that, in a Northern country where population growth has been high in the past and which still has a certain number of people, food prices can remain at high levels.

11.4.2 Economic Growth and Income Gaps

With respect to μ, the result for a Northern country is $\frac{dp^{j*}}{d\mu} > (<) 0$ $(j = N, S)$ if the values of c^N and c^S are sufficiently low (high), while the result for a Southern country is $\frac{dP^{j*}}{d\mu} > (<) 0$ $(j = N, S)$ if the values of g, c^N, and c^S are sufficiently high (low). Here, a rise in μ means a rise in a country's income level. Taking these into account, we have

Theorem 11.2 *For a Northern (Southern) country, economic growth raises the price of both Northern and Southern food if the production costs of Northern and Southern firms are low (if the income gap of the country and the production costs for Northern and Southern firms are large).*

As for Theorem 11.2, from the direct effects, $\frac{dp^N}{d\mu} > 0$, $\frac{dp^S}{d\mu} < 0$, $\frac{dP^N}{d\mu} > 0$, and $\frac{dP^S}{d\mu} < 0$, it is said that economic development increases general affluence, increases the ratio of rich (who have a preference for safer food) to poor, prevents more people from demanding questionable, low-priced food, and induces N-firm to want to sell safe food at a higher price and S-firm to attempt to sell questionable food at a lower price. At the same time, the indirect effect through the strategic complementarity of price competition makes the price of N-food lower and the price of S-food higher. This strategic pricing disturbs the consumer psychology regarding obtaining safer food and makes the direction of price change unclear.

Additionally, what transmits a price hike in safe foods to questionable food and causes the increased price of questionable food is (i) in the North lower production costs, which imply lower prices, and (ii) in the South higher production costs, which imply higher prices and a large income gap. This implies that in the North (South), where a decline in population (a growth in population) will be sustained owing to economic growth, a hike in food prices is caused by economic growth because prices were originally low (because of the high cost of production).

With respect to g, because the results are $\frac{dp^{j*}}{dg} > 0$ and $\frac{dP^{j*}}{dg} > 0$ $(j = N, S)$ and a rise in g means population growth accompanied by the expansion of the income gap, we arrive at

Theorem 11.3 *Regardless of whether the country belongs to the North or South, population growth accompanied by an expanding income gap increases the price of food made in both the North and the South.*

Theorem 11.3 is caused by the direct effects $\frac{dp^j}{dg} > 0$ and $\frac{dP^j}{dg} > 0$ $(j = N, S)$ and is likely a consequence of population growth. The reason for this result is the constant level of μ despite the expansion of the income gap or the stable income level of the country.

11.4.3 Health Hazards

With respect to m and D, the effects on the price of N-food are $\frac{dp^{N*}}{dm} > 0$, $\frac{dP^{N*}}{dm} > 0$, $\frac{dp^{N*}}{dD} > 0$, and $\frac{dP^{N*}}{dD} > 0$. Likewise, the effects on the price of S-food are $\frac{dp^{S*}}{dm} < (>)\, 0$, $\frac{dp^{S*}}{dD} < (>)\, 0$, $\frac{dP^{S*}}{dm} < (>) 0$, and $\frac{dP^{S*}}{dD} < (>)\, 0$, if p^S is low (high) enough that the difference between p^N and p^S is sufficiently large (small). Accordingly, we arrive at

Theorem 11.4 *Regardless of whether a country belongs to the North or South, (I) A rise in the probability or the extent of health damage raises the price of Northern food. (II) A rise in the probability or the extent of health damage reduces the price of Southern food if there is a large price difference between Northern food and Southern food.*

First, the direct effects in a Northern country are $\frac{dp^N}{dm} > 0$ and $\frac{dp^N}{dD} > 0$, although the signs of $\frac{dp^S}{dm}$ and $\frac{dp^S}{dD}$ are unclear, and the direct effects in a Southern country are $\frac{dP^N}{dm} > 0$, $\frac{dP^S}{dm} < 0$, $\frac{dP^N}{dD} > 0$, and $\frac{dP^S}{dD} < 0$. This implies that an increase in health hazard essentially makes people prefer safe food; N-firm sells safe food at a higher price, whereas at least in the Southern case, S-firm sells questionable food at a lower price. Thus, a hike in the price of safe food seems to reflect those plausible direct effects; a hike in the price of questionable food is likely based on the indirect effect of the strategic complementarity that makes S-food high priced. In addition, a higher price of S-food that corresponds to a smaller price differentiation may be based on a lower health hazard, leading to a more complementary relationship between both types of food.

Finally, with respect to q, the results are $\frac{dp^{N*}}{dq} > 0$, $\frac{dp^{S*}}{dq} < 0$, $\frac{dP^{N*}}{dq} > 0$, and $\frac{dP^{S*}}{dq} < 0$. Subsequently we find that

Theorem 11.5 *Regardless of whether the country belongs to the North or the South, a rise in basic food quality increases the price of Northern food and decreases the price of Southern food.*

Theorem 11.5 reflects the direct effects, $\frac{dp^N}{dq} > 0$, $\frac{dp^S}{dq} < 0$, $\frac{dP^N}{dq} > 0$, and $\frac{dP^S}{dq} < 0$, whereas the indirect effects through Bertrand competition are small and of little importance. In other words, although the basic quality of food bears no relationship to health hazards prima facie, it influences food price as if it were an index of safety. The assumed reason for this is that basic quality is one attraction for the consumer who chooses safe food, whereas this factor is less important for the consumer of S-food, who prefers cheaper goods.

11.5 Policy Implications

National income levels are variously involved in the domestic food market, and personal income levels also affect individuals' food preferences. Typically, the poor, who tend to be sensitive to food prices, are apt to disregard and be exposed to health hazards that can be caused by low-priced food. Even if low-priced food brings safety problems, however, this food fills the important role of nourishing the poor at low prices. Hence, an extreme policy, such as the policy by Northern governments that excludes low-priced food made in the South, is considered unsuitable from the viewpoint not only of the spirit of the WTO and diplomatic relations but also food security. Accordingly, food price hikes are one frequently occurring factor with a significant effect on the food market as a burden on consumers and are likely to hinder the full supply of low-priced food and/or exacerbate food safety problems caused by low-priced food.

This chapter theoretically studies the impact of economic growth coupled with demographic transition and food safety on food prices. The results of our analysis show that the sources of food price hikes are as follows: (a) *economic growth* and (b) *population growth accompanied by the expansion of the income gap* (see Theorems 11.2 and 11.3), regardless of whether a country belongs to the North or South and whether the safety of said food is guaranteed or problematic. We also find that (c) *remarkable population growth in the past* contributes to soaring food prices (see Theorem 11.1). Moreover, it is revealed that regardless of whether a country belongs to the North or South, (d) *the deterioration in the safety of foods made in the South* increases the price of safe food made in the North (see Theorem 11.4). We must also take note of another side of (d), however, namely, that it may reduce the price of problematic foods made in the South.

Here, it is supposed that hikes in food prices in the South are essentially caused by (a) and (b), suppressing the lives of people. This is because, on the basis of *Kuznets's inverted U-curve hypothesis*, the income gap expands at an early stage of economic development, as experienced in China and India in recent years, and does not begin to shrink until a later stage (see Kuznets (1955)). We can thus consider that (a) (economic growth) triggers (b) (the expansion of the income gap with population growth) in the Southern countries. Namely, it is said that in the South, *food price hikes are caused by the process of economic development itself*. In addition, it is said that because Southern countries have many poor people, an increase in the difference in price between safe food and problematic food, which can be caused by (d), causes more harm to the poor and aggravates the problem of food security and safety.

Likewise, it is supposed that food price hikes in the North are basically caused by (a), although (c) is also a cause of high food prices. However, negative population growth tends to cause food prices to fall. Then, as for Northern economies that shifted from a period of high growth to one of stable growth, at the point when their populations pass their peaks and begin to decline, the effects of (a) and (c) on food prices are weakened and considered to be moderate and/or unstable. In contrast, (d) will become a notable cause of food price hikes for wealthy Northern individuals, many of whom have a preference for safe food.

Based on the above considerations, we argue that certain types of political support are better suited to maintain stable food prices, food security, and food safety. First, in the North, because the effect of (d) on food prices is less ambiguous compared with the effects of changes in the population and income levels, Northern countries should consider policy supporting sanitary supervision of the food industry in the South, including technical assistance, management support, and so on. Likewise, from the perspective of (d), enforcing policies that prevent the expansion of health damage in the Northern domestic market is likely to be effective: e.g., “monitoring at the border and the distribution channel” and “introduction of a certification system which promotes food producers’ sound operation.” That is, guaranteeing food safety with high reliability brings about stable food prices. Of course, this also holds true for the policies of Southern governments.

Here, we must note that in our model, the consumers are located in only one country (a Northern country or a Southern county) for simplicity. If we model the world economy in which both types of countries have consumers, the results would show that economic growth and demographic transition in the South affect food prices in the North or global food prices through corresponding demand functions.

Unfortunately, as above, food price hikes are inseparable from economic advancement in the South. Subsequently, there may be no sweeping countermeasure that can combat price hikes in view of economic and population growth coupled with the expansion of the income gap of the South as long as these phenomena continue. Encouraging policies that artificially lead stable food prices and ensure food safety from the viewpoint of consumer protection will play an important role in improving the problems that accompany food price hikes caused by those factors, especially in Southern countries.

In terms of the details of such policy support, government regulations concerning food prices and business support appear to be helpful, although governments must take care in their handling of such policies. For example, Mariano and Giesecke (2014) examined the policies of “a ceiling on prices paid by rice consumers,” “a floor on prices received by paddy producers,” and “a subsidy on prices paid for seeds by paddy farmers” and found that those programs made a small contribution to food security *for a modest budgetary outlay*. Second, a policy that does not require significant additional government spending, such as a flexible reduction in tariff rate on a food product that faces the price hike, can be considered. Third, because personal income levels strongly mediate food purchasing behavior, as described above, if the government implements a public assistance and social security system that reflects the extent of the food price hike, the problems accompanying the food price hike can be mitigated, especially in Southern countries with larger impoverished populations. Specifically, such a policy that links the level of income support or consumption tax rates to a surge in food price can guarantee hygienic demand for food for the poor.

Acknowledgements This chapter has been published in *Economic Modeling*. I appreciate that Elsevier gave me permission to reprint it in our volume. Okimoto gratefully acknowledges the editors (Sushanta Mallick and Stephen George Hall), anonymous referees, Makoto Tawada (Aichi-Gakuin University), Akihiko Yanase (Nagoya University), Mitsuyoshi Yanagihara (Nagoya University), Hikaru Ogawa (University of Tokyo), Nobuyoshi Yamori (Kobe University), and the financial support of a Grant-in-Aid for JSPS Fellows #23-3981 from JSPS.

Appendix A: Stability Conditions

A.1. Case of a Developed Country in the North

Thanks to Condition 11.2, the sign of the stability condition is obtained by

$$\left.\frac{dp^N}{dp^S}\right|_S - \left.\frac{dp^N}{dp^S}\right|_N$$

$$\Leftrightarrow \frac{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]+y\left(\frac{p^S-c^S}{mD}\right)}{\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\left(\frac{p^S-c^S}{mD}\right)} - \frac{\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\left(\frac{p^N-c^N}{mD}\right)}{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\left(\frac{p^N-c^N}{mD}\right)}$$

$$\Leftrightarrow \left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]$$

$$\times\left\{3\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\left(\frac{p^N-c^N}{mD}\right)+y\left(\frac{p^S-c^S}{mD}\right)\right\} > 0.$$

A.2. Case of a Developing Country in the South

The sign of the stability condition is obtained by

$$\left.\frac{dP^N}{dP^S}\right|_S - \left.\frac{dP^N}{dP^S}\right|_N \Leftrightarrow \frac{2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\left(\frac{P^S-c^S}{mD}\right)}{\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\left(\frac{P^S-c^S}{mD}\right)} - \frac{\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\left(\frac{P^N-c^N}{mD}\right)}{2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\left(\frac{P^N-c^N}{mD}\right)} > 0.$$

Appendix B: Comparative Statics

B.1. Case of a Developed Country in the North

$$
\frac{1}{mD}\begin{bmatrix} -\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}\right\}, & \bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{\left(p^N-c^N\right)}{mD} \\ \bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}, & -\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\frac{\left(p^S-c^S\right)}{mD}\right\} \end{bmatrix}
$$

$$
\times\begin{bmatrix} dp^N \\ dp^S \end{bmatrix}
$$

$$
=\begin{bmatrix} \frac{1}{2}\left(\mu+\frac{g}{2}\right)^2-\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(p^N-c^N\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right) \\ -\frac{1}{2}\left(\mu-\frac{g}{2}\right)^2+\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(p^S-c^S\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right) \end{bmatrix}dy
$$

$$
+\begin{bmatrix} -\left[\bar{L}-y\left(\mu+\frac{g}{2}\right)\right] \\ \bar{L}-y\left(\mu-\frac{g}{2}\right) \end{bmatrix}d\mu
$$

$$
-\frac{1}{2}\begin{bmatrix} \bar{L}-y\left(\mu+\frac{g}{2}\right) \\ \bar{L}-y\left(\mu-\frac{g}{2}\right) \end{bmatrix}dg+\frac{1}{2D\sqrt{q}}\begin{bmatrix} -\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{\left(p^N-c^N\right)}{mD}\right] \\ \bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD} \end{bmatrix}dq
$$

$$
-\frac{1}{m}\begin{bmatrix} \left[\frac{\left(p^N-p^S\right)}{mD}\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{\left(p^N-c^N\right)}{mD}\right] + \frac{\left(p^N-c^N\right)}{mD}\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\right] \\ \left[-\frac{\left(p^N-p^S\right)}{mD}\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}\right] + \frac{\left(p^S-c^S\right)}{mD}\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\right] \end{bmatrix}dm
$$

$$
+\frac{1}{D}\begin{bmatrix} \left[-\left\{\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{\left(p^N-c^N\right)}{mD}\right] + \frac{\left(p^N-c^N\right)}{mD}\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\right\}\right] \\ \left[\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}\right] - \frac{\left(p^S-c^S\right)}{mD}\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\right] \end{bmatrix}dD
$$

$$
-\begin{bmatrix} \left(\mu+\frac{g}{2}\right)-\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-\frac{\left(p^N-c^N\right)}{mD} \\ \left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-\left(\mu-\frac{g}{2}\right)-\frac{\left(p^S-c^S\right)}{mD} \end{bmatrix}d\bar{L}.
$$

Taking Condition 11.2 into account, we have

$$\left|J^N\right| = \frac{1}{(mD)^2}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]$$
$$\times\left\{3\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD} + y\frac{\left(p^S - c^S\right)}{mD}\right\} > 0.$$

If the values of g, c^N, and c^S are sufficiently high (low), the results with respect to $\bar{L}$ and y are as follows:

$$(mD)\left|J^N\right|\frac{dp^{N*}}{d\bar{L}}$$
$$= \left[\left(\mu + \frac{g}{2}\right) - \left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \frac{\left(p^N - c^N\right)}{mD}\right]$$
$$\times\left\{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}\right\}$$
$$+\left[\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \left(\mu - \frac{g}{2}\right) - \frac{\left(p^S - c^S\right)}{mD}\right]$$
$$\times\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - y\frac{\left(p^N - c^N\right)}{mD}\right]$$
$$= \frac{y}{\bar{L}}\left[\frac{1}{2}\left(\mu + \frac{g}{2}\right)^2 - \frac{1}{2}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \frac{\left(p^N - c^N\right)}{mD}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]$$
$$\times\left\{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}\right\}$$
$$+\frac{y}{\bar{L}}\left[\frac{1}{2}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \frac{1}{2}\left(\mu - \frac{g}{2}\right)^2 - \frac{\left(p^S - c^S\right)}{mD}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]$$
$$\times\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - y\frac{\left(p^N - c^N\right)}{mD}\right] > (<)\, 0,$$

(∵ Eqs. (11.9) and (11.10))

$$
\begin{aligned}
&(mD)\left|J^N\right|\frac{dp^{S*}}{d\bar{L}}\\
&=\left[\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-\left(\mu-\frac{g}{2}\right)-\frac{\left(p^S-c^S\right)}{mD}\right]\\
&\quad\times\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}\right\}\\
&\quad+\left[\left(\mu+\frac{g}{2}\right)-\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-\frac{\left(p^N-c^N\right)}{mD}\right]\\
&\quad\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}\right]\\
&=\frac{y}{\bar{L}}\left[\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{1}{2}\left(\mu-\frac{g}{2}\right)^2-\frac{\left(p^S-c^S\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\\
&\qquad\times\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}\right\}\\
&\quad+\frac{y}{\bar{L}}\left[\frac{1}{2}\left(\mu+\frac{g}{2}\right)^2-\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(p^N-c^N\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\\
&\qquad\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}\right]>(<)\,0,\\
&\qquad(\because \text{Eqs. (11.9) and (11.10)})
\end{aligned}
$$

$$
\begin{aligned}
&-(mD)\left|J^N\right|\frac{dp^{N*}}{dy}\\
&=\left[\frac{1}{2}\left(\mu+\frac{g}{2}\right)^2-\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(p^N-c^N\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\\
&\qquad\times\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]+y\frac{\left(p^S-c^S\right)}{mD}\right\}\\
&\quad+\left[\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{1}{2}\left(\mu-\frac{g}{2}\right)^2-\frac{\left(p^S-c^S\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\\
&\qquad\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{\left(p^N-c^N\right)}{mD}\right]>(<)\,0,
\end{aligned}
$$

$$
\begin{aligned}
&-(mD)\left|J^N\right|\frac{dp^{S*}}{dy}\\
&=\left[\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{1}{2}\left(\mu-\frac{g}{2}\right)^2-\frac{\left(p^S-c^S\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\\
&\qquad\times\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}\right\}\\
&\quad+\left[\frac{1}{2}\left(\mu+\frac{g}{2}\right)^2-\frac{1}{2}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(p^N-c^N\right)}{mD}\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\\
&\qquad\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}\right]>(<)\,0.
\end{aligned}
$$

If the values of c^N and c^S are sufficiently low (high), the results with respect to μ are as follows:

$$
\begin{aligned}
&(mD)\left|J^N\right|\frac{dp^{N*}}{d\mu}\\
&=\left[\bar{L}-y\left(\mu+\frac{g}{2}\right)\right]\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]+y\frac{\left(p^S-c^S\right)}{mD}\right\}\\
&\quad-\left[\bar{L}-y\left(\mu-\frac{g}{2}\right)\right]\left\{\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}\right\}>(<)\,0,
\end{aligned}
$$

$$
\begin{aligned}
&(mD)\left|J^N\right|\frac{dp^{S*}}{d\mu}\\
&=-\left[\bar{L}-y\left(\mu-\frac{g}{2}\right)\right]\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}\right\}\\
&\quad+\left[\bar{L}-y\left(\mu+\frac{g}{2}\right)\right]\left\{\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]+y\frac{\left(p^S-c^S\right)}{mD}\right\}>(<)\,0.
\end{aligned}
$$

The results with respect to g are as follows (the signs are determinate):

$$
\begin{aligned}
&(mD)\left|J^N\right|\frac{dp^{N*}}{dg}\\
&=\frac{1}{2}\left[\bar{L}-y\left(\mu+\frac{g}{2}\right)\right]\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]+y\frac{\left(p^S-c^S\right)}{mD}\right\}
\end{aligned}
$$

$$+\frac{1}{2}\left[\bar{L}-y\left(\mu-\frac{g}{2}\right)\right]\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{\left(p^N-c^N\right)}{mD}\right]>0,$$

$$(mD)\left|J^N\right|\frac{dp^{S*}}{dg}$$
$$=\frac{1}{2}\left[\bar{L}-y\left(\mu-\frac{g}{2}\right)\right]\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}\right\}$$
$$+\frac{1}{2}\left[\bar{L}-y\left(\mu+\frac{g}{2}\right)\right]\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}\right]>0.$$

The results with respect to m and D are as follows:

$$m^2D\left|J^N\right|\frac{dp^{N*}}{dm}=$$
$$\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]\Big\langle\left[\frac{(p^N-p^S)}{mD}+\frac{(p^S-c^S)}{mD}\right]$$
$$\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{(p^N-c^N)}{mD}\right]$$
$$+\frac{(p^N-c^N)}{mD}\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]+y\frac{(p^S-c^S)}{mD}\right\}\Big\rangle>0,$$

$$\left(m^2D\right)\left|J^N\right|\frac{dp^{S*}}{dm}=$$
$$\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]$$
$$\times\Big\langle\frac{(p^S-c^S)}{mD}\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{(p^N-c^N)}{mD}\right\}$$
$$-\left[\frac{(p^N-p^S)}{mD}-\frac{(p^N-c^N)}{mD}\right]\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{(p^S-c^S)}{mD}\right]\Big\rangle,$$

$$m\,(D)^2\left|J^N\right|\frac{dp^{N*}}{dD}=$$
$$\Big\langle\left[\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+\frac{(p^S-c^S)}{mD}\right]$$

$$\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{(p^N-c^N)}{mD}\right]$$
$$+\frac{(p^N-c^N)}{mD}\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]+y\frac{(p^S-c^S)}{mD}\right\}\Big\rangle$$
$$\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]>0,$$

$$m(D)^2\left|J^N\right|\frac{dp^{S*}}{dD}=$$
$$\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]$$
$$\times\Big\langle\frac{(p^S-c^S)}{mD}\left\{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{(p^N-c^N)}{mD}\right\}$$
$$-\left[\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-\frac{(p^N-c^N)}{mD}\right]$$
$$\times\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{(p^S-c^S)}{mD}\right]\Big\rangle.$$

The conditions that determine the signs of $\frac{dp^{S*}}{dm}$ and $\frac{dp^{S*}}{dD}$ are as follows:

$$\frac{dp^{S*}}{dm}<0\Leftrightarrow\left(p^S-c^S\right)\frac{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}}{\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}}$$
$$+\left(p^N-c^N\right)<\left(p^N-p^S\right),$$

$$\frac{dp^{S*}}{dD}<0\Leftrightarrow\left(p^S-c^S\right)\frac{2\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]-y\frac{\left(p^N-c^N\right)}{mD}}{\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}}$$
$$+\left(p^N-c^N\right)<\left(p^N-p^S-m\sqrt{q}\right).$$

The results with respect to q are as follows (the signs are determinate):

$$2m\sqrt{q}\,(D)^2\left|J^N\right|\frac{dp^{N*}}{dq}$$
$$=\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)-y\frac{\left(p^N-c^N\right)}{mD}\right]\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]>0,$$

$$2m\sqrt{q}\,(D)^2\left|J^N\right|\frac{dp^{S*}}{dq}$$

$$=-\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+y\frac{\left(p^S-c^S\right)}{mD}\right]\left[\bar{L}-y\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)\right]<0.$$

B.2. Case of a Developing Country in the South

$$\frac{1}{mD}\begin{bmatrix}-\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right], & \left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD} \\ \left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}, & -\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]\end{bmatrix}\begin{bmatrix}dP^N \\ dP^S\end{bmatrix}$$

$$=\begin{bmatrix}0\\0\end{bmatrix}dx+\begin{bmatrix}-\left(\mu+\frac{g}{2}\right)\\ \left(\mu-\frac{g}{2}\right)\end{bmatrix}d\mu-\frac{1}{2}\begin{bmatrix}\left(\mu+\frac{g}{2}\right)\\ \left(\mu-\frac{g}{2}\right)\end{bmatrix}dg$$

$$+\frac{1}{2D\sqrt{q}}\begin{bmatrix}-\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]\\ \left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\end{bmatrix}dq$$

$$-\frac{1}{m}\begin{bmatrix}\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]\frac{\sqrt{q}}{D}\\ +2\left[\frac{1}{2}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)^2+\frac{\left(P^N-c^N\right)}{mD}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\right]\\ -\left\{\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]\frac{\sqrt{q}}{D}\right.\\ \left.+2\left[\frac{1}{2}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(P^S-c^S\right)}{mD}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\right]\right\}\end{bmatrix}dm$$

$$+\frac{1}{D}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\begin{bmatrix}-\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+2\frac{\left(P^N-c^N\right)}{mD}\right]\\ \left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\end{bmatrix}dD.$$

Because Eq. (11.14) demonstrates that $2\left(P^N-P^S-m\sqrt{q}\right)-\left(P^S-c^S\right)>0$, we have

$$\left|J^S\right|=\frac{1}{(mD)^2}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)$$
$$\times\left[3\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}+\frac{\left(P^N-c^N\right)}{mD}\right]>0.$$

If the values of g, c^N, and c^S are sufficiently high (low), the results are as follows:

$$(mD)\left|J^S\right|\frac{dP^{N*}}{d\mu}=\left(\mu+\frac{g}{2}\right)\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]$$
$$-\left(\mu-\frac{g}{2}\right)\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]>(<)\,0,$$

$$(mD)\left|J^S\right|\frac{dP^{S*}}{d\mu}=\left(\mu+\frac{g}{2}\right)\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]$$
$$-\left(\mu-\frac{g}{2}\right)\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]>(<)\,0.$$

The results with respect to g are as follows (the signs are determinate):

$$(mD)\left|J^S\right|\frac{dP^{N*}}{dg}=\frac{1}{2}\left(\mu+\frac{g}{2}\right)\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]$$
$$+\frac{1}{2}\left(\mu-\frac{g}{2}\right)\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]>0,$$

$$(mD)\left|J^S\right|\frac{dP^{S*}}{dg}=\frac{1}{2}\left(\mu-\frac{g}{2}\right)\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]$$
$$+\frac{1}{2}\left(\mu+\frac{g}{2}\right)\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]>0.$$

The results with respect to m and D are as follows:

$$m^2D\left|J^S\right|\frac{dP^{N*}}{dm}=\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)$$
$$\times\left\{\frac{\sqrt{q}}{D}\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]+\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\right.$$
$$\left.\times\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+3\frac{\left(P^N-c^N\right)}{mD}+\frac{\left(P^S-c^S\right)}{mD}\right]\right\}>0,$$

$$m^2D\left|J^S\right|\frac{dP^{S*}}{dm}=-\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)$$
$$\times\left\{\frac{\sqrt{q}}{D}\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]+\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\right.$$
$$\left.\times\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-3\frac{\left(P^S-c^S\right)}{mD}-\frac{\left(P^N-c^N\right)}{mD}\right]\right\},$$

$$m\left(D\right)^2\left|J^S\right|\frac{dP^{N*}}{dD}=\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)$$
$$\times\left\{\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)^2+\frac{\left(P^N-c^N\right)}{mD}\right.$$
$$\left.\times\left[3\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]\right\}>0,$$

$$m\left(D\right)^2\left|J^S\right|\frac{dP^{S*}}{dD}=-\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)$$
$$\times\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^N-c^N\right)}{mD}\right].$$

The conditions that determine the signs of $\frac{dP^{S*}}{dm}$ and $\frac{dP^{S*}}{dD}$ are as follows:

$$\frac{dP^{S*}}{dm}<0\Leftrightarrow m\sqrt{q}\frac{\left(P^N-P^S-m\sqrt{q}\right)-\left(P^S-c^S\right)}{P^N-P^S-m\sqrt{q}}$$
$$+\left(P^N-P^S-m\sqrt{q}\right)>3\left(P^S-c^S\right)+\left(P^N-c^N\right),$$

$$\frac{dP^{S*}}{dD}<0\Leftrightarrow\left(P^N-P^S-m\sqrt{q}\right)>\left(P^N-c^N\right).$$

The results with respect to q are as follows (the signs are determinate):

$$2m\sqrt{q}\left(D\right)^2\left|J^S\right|\frac{dP^{N*}}{dq}$$
$$=\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]>0,$$

$$2m\sqrt{q}\,(D)^2\left|J^S\right|\frac{dP^{S*}}{dq}$$
$$= -\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right)\left[\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right) - \frac{\left(P^S - c^S\right)}{mD}\right] < 0.$$

Appendix C: Nature of Reaction Functions

C.1. Case of a Developed Country in the North

$$\frac{dp^N}{d\bar{L}} = \frac{\left[\left(\mu + \frac{g}{2}\right) - \left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \frac{\left(p^N - c^N\right)}{mD}\right]mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD}}$$
$$= \frac{\frac{y}{\bar{L}}\left[\frac{1}{2}\left(\mu + \frac{g}{2}\right)^2 - \frac{1}{2}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \frac{\left(p^N - c^N\right)}{mD}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD}},$$

(∵ Eq. (11.9))

$$\frac{dp^S}{d\overline{L}} = \frac{\left[\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - \left(\mu - \frac{g}{2}\right) - \frac{\left(p^S - c^S\right)}{mD}\right]mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}}$$
$$= \frac{\frac{y}{\bar{L}}\left[-\frac{1}{2}\left(\mu - \frac{g}{2}\right)^2 + \frac{1}{2}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \frac{\left(p^S - c^S\right)}{mD}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}},$$

(∵ Eq. (11.10))

$$\frac{dp^N}{dy} = -\frac{\left[\frac{1}{2}\left(\mu + \frac{g}{2}\right)^2 - \frac{1}{2}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \frac{\left(p^N - c^N\right)}{mD}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD}},$$

$$\frac{dp^S}{dy} = -\frac{\left[-\frac{1}{2}\left(\mu - \frac{g}{2}\right)^2 + \frac{1}{2}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)^2 - \frac{\left(p^S - c^S\right)}{mD}\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}},$$

$$\frac{dp^N}{d\mu} = \frac{\left[\bar{L} - y\left(\mu + \frac{g}{2}\right)\right] mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD}} > 0,$$

$$\frac{dp^S}{d\mu} = -\frac{\left[\bar{L} - y\left(\mu - \frac{g}{2}\right)\right] mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}} < 0,$$

$$\frac{dp^N}{dg} = \frac{\frac{1}{2}\left[\bar{L} - y\left(\mu + \frac{g}{2}\right)\right] mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD}} > 0,$$

$$\frac{dp^S}{dg} = \frac{\frac{1}{2}\left[\bar{L} - y\left(\mu - \frac{g}{2}\right)\right] mD}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}} > 0,$$

$$\frac{dp^N}{dm} = \frac{\left[\begin{array}{c}\left\{\frac{\left(p^N - p^S\right)}{mD}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - y\frac{\left(p^N - c^N\right)}{mD}\right]\right. \\ \left. + \frac{\left(p^N - c^N\right)}{mD}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]\right\} D\end{array}\right]}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD}} > 0,$$

$$\frac{dp^S}{dm} = \frac{\left[\begin{array}{c}\left\{-\frac{\left(p^N - p^S\right)}{mD}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) + y\frac{\left(p^S - c^S\right)}{mD}\right]\right. \\ \left. + \frac{\left(p^S - c^S\right)}{mD}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]\right\} D\end{array}\right]}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{\left(p^S - c^S\right)}{mD}},$$

$$\frac{dp^N}{dD} = \frac{\left[\begin{array}{c}\left\{\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - y\frac{\left(p^N - c^N\right)}{mD}\right]\right. \\ \left. + \frac{\left(p^N - c^N\right)}{mD}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]\right\} m\end{array}\right]}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{\left(p^N - c^N\right)}{mD}} > 0,$$

$$\frac{dp^S}{dD} = \frac{\left[\begin{array}{l} -\left\{\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) + y\frac{(p^S - c^S)}{mD}\right]\right. \\ \quad \left. -\frac{(p^S - c^S)}{mD}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right]\right\} m \end{array}\right]}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{(p^S - c^S)}{mD}},$$

$$\frac{dp^N}{dq} = \frac{\frac{1}{2\sqrt{q}}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) - y\frac{(p^N - c^N)}{mD}\right] m}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] - y\frac{(p^N - c^N)}{mD}} > 0,$$

$$\frac{dp^S}{dq} = -\frac{\frac{1}{2\sqrt{q}}\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right) + y\frac{(p^S - c^S)}{mD}\right] m}{2\left[\bar{L} - y\left(\frac{p^N - p^S - m\sqrt{q}}{mD}\right)\right] + y\frac{(p^S - c^S)}{mD}} < 0,$$

C.2. Case of a Developing Country in the South

$$\frac{dP^N}{d\mu} = \frac{\left(\mu + \frac{g}{2}\right) mD}{2\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right) + \frac{(P^N - c^N)}{mD}} > 0, \quad \frac{dP^S}{d\mu} = -\frac{\left(\mu - \frac{g}{2}\right) mD}{2\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right) - \frac{(P^S - c^S)}{mD}} < 0,$$

$$\frac{dP^N}{dg} = \frac{\frac{1}{2}\left(\mu + \frac{g}{2}\right) mD}{2\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right) + \frac{(P^N - c^N)}{mD}} >, \quad \frac{dP^S}{dg} = \frac{\frac{1}{2}\left(\mu - \frac{g}{2}\right) mD}{2\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right) - \frac{(P^S - c^S)}{mD}} > 0,$$

$$\frac{dP^N}{dm} = \frac{\left[\begin{array}{l} \left\{\left[\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right) + \frac{(P^N - c^N)}{mD}\right]\frac{\sqrt{q}}{D}\right. \\ \quad \left. +2\left[\frac{1}{2}\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right)^2 + \frac{(P^N - c^N)}{mD}\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right)\right]\right\} D \end{array}\right]}{\left[2\left(\frac{P^N - P^S - m\sqrt{q}}{mD}\right) + \frac{(P^N - c^N)}{mD}\right]} > 0,$$

$$\frac{dP^S}{dm}=-\frac{\left[\begin{array}{l}\left\{\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]\frac{\sqrt{q}}{D}\right.\\ \left.\quad+2\left[\frac{1}{2}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)^2-\frac{\left(P^S-c^S\right)}{mD}\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\right]\right\}D\end{array}\right]}{\left[2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]}<0,$$

$$\frac{dP^N}{dD}=\frac{\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{2\left(P^N-c^N\right)}{mD}\right]m}{2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}}>0,$$

$$\frac{dP^S}{dD}=-\frac{\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]m}{2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}}<0,$$

$$\frac{dP^N}{dq}=\frac{\frac{1}{2\sqrt{q}}\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)+\frac{\left(P^N-c^N\right)}{mD}\right]m}{2\left(\frac{p^N-p^S-m\sqrt{q}}{mD}\right)+\frac{\left(p^N-c^N\right)}{mD}}>0,$$

$$\frac{dP^S}{dq}=-\frac{\frac{1}{2\sqrt{q}}\left[\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}\right]m}{2\left(\frac{P^N-P^S-m\sqrt{q}}{mD}\right)-\frac{\left(P^S-c^S\right)}{mD}}<0.$$

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Web Resources

Ministry of Agriculture, Forestry and Fisheries, http://www.maff.go.jp/e/index.html. National Health Interview Survey, http://www.cdc.gov/nchs/nhis.htm.